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INTRODUCTION TO MILITARY PROGRAM MANAGEMENT

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LOGISTICS MANAGEMENT INSTITUTE

INTRODUCTION TO
MILITARY PROGRAM MANAGEMENT

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The importance I attach to program management in the acquisition of major weapon systems led to the preparation of this document: Introduction to Military Program Management. I thought we needed something which would capture some of the spirit of program management, illuminate the objectives of our policies for the acquisition of major systems, and build on the recent experience of active program managers.

I believe that military program managers will benefit from a thoughtful reading of this volume. At the same time, I would emphasize that it is not an official document. It does not purport to establish DoD policy, and in no way affects responsibility of the Services for the definition and execution of their programs.

David Packard

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INTRODUCTION

Purpose

This volume is intended to be a source of hints, something of lessons learned, and pitfalls seen by program managers. The writers approached their task in the spirit of being helpful and mercifully brief. Whatever else may be lacking, the manager of a weapon system acquisition program cannot complain of any shortage of reading material with liberal references to even longer and less interesting works. We have tried to focus on the "art" of program management--and much of what we say is really a reminder about things already known, but often forgotten in the effort to cope with day-to-day crises. If at times we sound like we are lecturing about the obvious, it is because we are convinced that what can be communicated in management are only the fundamentals--the concepts that will prompt the program manager to introspective thought about his goals and his techniques of management. This volume is not a bible, nor a handbook on program management. Most important, it is not directive in intent--and, hopefully, not directive in tone.

The question might now be raised, since it will not be formally addressed later: "What is management?" A complete answer would certainly unbalance this book; a short answer would be inadequate. We refer you instead to the 799 pages of a standard treatise on the subject, and the many selected references following each chapter, in Harold Koontz and Cyril O'Donnell, Principles of Management, McGraw-Hill, 1968.

Having now mastered the principles of management--planning, organizing, staffing, directing, controlling, and the changing environment of management--we can turn directly to military program management.

Organization

Chapter One discusses the concept of military program management, the role of the program manager, and his relationship to the Service organizations and to the Office of the Secretary of Defense (OSD). Chapter Two discusses program objectives and trade-offs within the envelope of system requirements. That chapter also covers system planning, risk assessment, and risk reduction. Chapter Three takes up program interface with contractors and some of the more significant implications in the contracting process. The next three chapters discuss some problems affecting system objectives of performance, schedule, and cost. The order of mention is not intended to indicate an order of preference or importance. Indeed, a major theme of this guide is that performance, schedule, and cost are three inextricably interwoven parts of one system envelope. In Chapter Seven we discuss some ways to increase the effectiveness of the program manager.

Acknowledgements

It will be obvious to the reader that we are indebted to more people in the Department of Defense and in industry than we can acknowledge. Without their guidance and advice, and the generous contribution of their time and thoughts, we could not have attempted to focus on the real world of program management. Most important, of course, were the contributions of present and past military program managers who, in fact, best know the real world of military program management. The program managers we interviewed understood that none would be quoted directly. We have tried to capture some of their thoughts and words in the quotations we have used--many of which are paraphrases and composites of the remarks of several contributors.

References

The books and articles referenced in the footnotes have been selected to direct the reader to sources which have special relevance and practical guidance for military program managers.

CHAPTER ONE

THE WORLD OF PROGRAM MANAGEMENT

The Role of the Program Manager

A fundamental Department of Defense (DoD) policy is that the acquisition of major weapon systems will be directed by responsible managers under the concept of program management.

The concept of program management is to provide centralized management authority over all of the technical and business aspects of a program. The program manager's role, then, is to tie together, to manage, to direct the development and production of a system meeting performance, schedule, and cost objectives which are defined by his Service and approved by the Secretary of Defense (SECDEF). The essence of the program manager's role is to be the agent of the Service in the management of the system acquisition process, to focus the authority and responsibility of the Service for running the program. He has the vantage of a large perspective of the program and the interrelationships among its elements. He must be the major motive force for propelling the system through its evolution.

Recently, a panel of military program managers examining their role likened it to that of the general manager of a small company. The comparison is especially apt. It would be impossible to write a meaningful position description for that job. It is equally impossible to write one for the program manager's job. What the general manager does is whatever is needed to move the affairs of the business. He does one thing at one time and another thing at another time--whatever is most needed

at the moment to achieve his objectives. A general manager is not a "doer" of any job--there are other managers charged with the doing. But the general manager sees to it that what he wants is done, and what he wants is a harmony of things done so that his objectives are achieved. The role implies reliance on others to do the work; but it also implies controlling and coordinating the work so that no one aspect dominates others to the detriment of the harmony of the whole.

This touches upon what is likely to be the most important function of the program manager: getting people to communicate with each other to achieve a common understanding of the needs of the program and their place in the harmony of the total program effort.

Service Responsibility

It is some oversimplification, but basically correct, to identify three players and their respective roles: the Service, the program manager, and OSD. The Service is responsible for identifying its operational needs and defining the new systems required to meet those needs. It is also reponsible for the formulation of plans for the orderly development and production of the systems. The program manager is the agent of the Service for the formulation and execution of the plan. OSD is the keeper of the Service conscience--it reviews and approves the Service plan and program. But the center of systems acquisition authority and responsibility lies in the Service--more specifically, it is the Service Secretary.

Approval improperly exercised means direction in practice. It is possible to withhold approval until the one approach desired by the approving authority is reluctantly proposed (or stumbled upon) by the organization or person seeking the approval. That way of

exercising approval is directing--albeit obliquely. He who exercises "approval" power in that mode is seen to have assumed the role of directing, while perhaps planning to dodge responsibility if things go wrong.

Approval means something else, especially in the context of OSD's role in military program management. It denotes a dictionary definition of the word approval: "to accept as satisfactory." That is to say, it is the Service's role to formulate the system requirements and plan for implementation. It is OSD's role to accept the Service's product as satisfactory--provided it is consistent with major policy objectives. It is also OSD's role to evaluate the performance of the Services in implementing the approved programs. But the Service has the final responsibility for getting the job done.

Judgment and Flexibility

The concept of program management evolved because the ordinary way of doing things was not adequate for the task of managing the acquisition of complex weapon systems. Extraordinary management--program oriented management--was essential if all of the aspects of the program were to be handled correctly and expeditiously.

To achieve this extraordinary management, there is another OSD policy which complements the policy requiring program management: military program managers should be free to exercise judgment and flexibility. Although the program manager is the agent of the Service, he should operate in an environment in which he selects and tailors to the specific needs of his program those management systems and formal techniques that will help his program. He should operate in an environment conducive to the exercise of judgment. There is no pet formula a program manager can adopt. He must decide for himself what

methods, techniques, and systems he will use. If the program manager is responsible for planning, directing, and controlling a program, he must have the authority to get the job done.

Stated another way, the program manager is encouraged to adapt standard techniques to the peculiar requirements of his program. In turn, he has a right to expect that those in the Services who are going to approve his management plans and techniques will exercise their power of approval properly. That is to say, his plans and techniques will be accepted as satisfactory if they comply with basic policy directives. He has a right to expect that his plans will not be judged by the standard of meticulous compliance with innumerable details hidden away in regulations, directives, instructions, handbooks, manuals, standards, specifications, or similar documents.

What the program manager has a right to expect and what in fact he will be offered are often quite different. Experienced program managers would remind the new program manager that often one must struggle to obtain the management flexibility he is supposed to be given. Higher authorities, and especially their staff organizations, tend to standardize their requirements and to insist on the use of familiar techniques and methods. Their initial disposition is to avoid changes and exceptions to the general rule. Requests for deviations are rarely conceded without being pushed and sold.

Functional Support

The use of judgment and the exercise of flexibility are difficult to achieve in the environment of military program management. The most significant reason for this

is that the operation of program management envisions two organizational elements. In some few cases the program office is staffed with all or most of the capability to perform the functional activities. In these cases the program office is largely self-sufficient and does not have to rely on much support from functional activities outside of the line authority of the program manager. Coordination is simplified, but the problems associated with organizing and staffing the program office are magnified. Usually, however, there is a small, centralized management authority consisting of the program manager and his program office. This office is served by functional organizations which support the centralized authority and which are responsible to it for the execution of assigned tasks. This environment, where the resources for doing the work are largely outside of the line authority of the program manager, is a natural source of conflict.

The practical fact is that there are usually several programs competing for the limited resources of the same functional organizations. Those functional elements are also supporting the normal activities of their parent organizations--the day-to-day, non-program activities. When personnel are not available to support all of the demands, the program manager finds less responsiveness than he desires from the functional elements. His situation is made even more difficult because the functional elements were there long before his program started and they plan to be there long after his program ends.

Another aspect of this problem is the tendency of functional specialists to see their discipline as the central core of a successful program. Their commitment to their specialty leads them to try to dictate to the

program what will or must be done--as distinguished from advising what should be done. Further, there is no lack of regulations with which they can bolster their claim. One of the most difficult concepts to put across to functional specialists is that the program manager is responsible for determining <u>what</u> will be done. The functional specialist is responsible for <u>how</u> it is done--the <u>how</u> being his area of expertise.

> There is a natural tendency for the functional managers to standardize their operations or efforts, to perform to standards, or to build a standard model. A project manager must, through his influence, force his functional areas to depart from a standard and build something that fits in with the other parts of the project. Someone has to force these people to take action when these actions increase a functional manager's risk or use his resources at a greater rate than he would otherwise. The project manager's role is to balance this risk over all portions of the project. Therefore, he must have authority to move quickly to balance his risk.*

Problems with functional specialists are not something new:

> The expert, in fact, simply by reason of his immersion in a routine, tends to lack flexibility of mind once he approaches the margins of his special theme. He is incapable of rapid adaptation to novel situations. He unduly discounts experience which does not tally with his own. He is hostile to views which are not set out in terms he has been accustomed to handle. No man is so adept at realizing difficulties within the field that he knows; but, also, few are so incapable of meeting situations outside that field. Specialism seems to breed a horror

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*George A. Steiner and William G. Ryan, <u>Industrial Project Management</u>, the Macmillan Company, 1968, p. 29.

> of unwonted experiment, a weakness in achieving adaptability, both of which make the expert of dubious value when he is in supreme command of a situation.*

The environment of program management therefore places an extraordinary premium on talent for leadership as distinguished from command, on persuasion as distinguished from direction. The environment requires an emphasis on informal authority, de facto authority, or influence as distinct from power. One student of program management has described this authority as derived in part from the program manager's "persuasive ability, his rapport with extra-organizational units, and his reputation in resolving opposing viewpoints within the parent unit and between the external organizations."**

Persuasion is not the only way to get things done. One defense program manager said that on many occasions he overcame the opposition of functional specialists by "working harder than they did." This program manager found that he could so overwhelm a specialist with facts, figures, and analysis that it became too much of an effort for the specialist to refute the program manager's position.

The comments of this program manager highlighted a point made by several others that there is a need for a strong analytical capability in the program office to

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*Harold J. Laski, "The Limitations of the Expert," Harper's Magazine, December 1930. Quoted in Specialists and Generalists, a selection of readings by the Committee on Government Operations, U. S. Senate, 90th Congress, 2d Session, 1968, p. 53.

**David I. Cleland, "Project Management," Air-University Review, Vol. XVI, No. 2, January-February, 1965. Reprinted in a book of readings compiled by David I. Cleland and William R. King, Systems, Organizations, Analysis, Management, McGraw-Hill Book Company, 1969.

coordinate a program whose parts were organizationally and geographically widely dispersed. A talent for analysis and ability to work with people were the key criteria in their selection of program office personnel.

Engagement and Disengagement

In common with the way a general manager must operate, the program manager relies on others to do the work. But he cannot escape the responsibility for the result. If he is responsible, he must be satisfied that what is done in his program makes sense to him and is consistent with his plans. If he cannot be persuaded that it is right for his program, he must direct it to be done the way he wants.

Much has been written about the role of industry and the relationship that should obtain between the defense program manager and his industry counterpart. Much has been said about "disengagement"--getting out of industry's hair and letting them do the job they have contracted to do. The goal is laudable and, the way it is stated, the idea is entirely consistent with good management concepts. But the ultimate responsibility for a successful program rests squarely on the Service and on the military program manager as its agent. The program manager cannot disengage in any literal sense. He must manage contracted work in just the same sense as he manages all the other parts of his program. More precisely, in this case he manages contractor management of his program. It is not a question of <u>whether</u> he manages; it is only a question of <u>how</u> he manages--or mismanages.

Industry project managers and government program managers are agreed on this point:

> It seems clear that the Government program manager must exercise rather tight control until

> such time as he is assured that the industrial project manager has the technical and managerial competence to perform as required.*

The obverse is equally true, however: Once the government program manager has obtained the assurance he needs, he should relax his control and concede to his contractors a measure of freedom to exercise judgment and flexibility similar to that which he seeks for himself.

The Soft Sell

Newly appointed program managers may be dismayed to discover that there is less than complete and enthusiastic support for their programs within their Service and OSD. Every weapon system competes with all the others for limited resources, and competition is especially fierce in periods of tight budgets. At every level in the hierarchy, commanders and staff personnel are confronted by demands from program and functional managers for far more money than is available or can reasonably be obtained. Budget recommendations and decisions must be made that will inevitably favor some programs over others.

The program manager who has done his homework and has kept key people informed about his system's problems and progress will improve the odds that funds for his program will not be reduced. We are not suggesting that a program manager affect a hard-sell stance or that he patrol corridors to buttonhole unwary staff people. What we are suggesting is that a program manager should be attuned to the information needs and biases of the people who influence budget decisions. This implies a kind of low-key salesmanship--of the soft-sell, helpful variety.

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*Steiner and Ryan, _op. cit_., p. 125.

> One of the project manager's greatest sources of authority involves the manner in which he builds alliances in his environment--with his peers, associates, superiors, subordinates, and other interested parties. The building of alliances supplements his legal authority; it is the process through which the project manager can translate disagreement and conflict into authority (or influence power) to make his decisions stand. Sometimes the power and control of the project manager represents a subtle departure from his legal authority.*

The program manager must keep in touch with what is going on above him. He has to be aware of what is expected of him by higher authority--both in his Service and at the OSD level. He should know the typical questions being asked at major program review points, and he should be aware that these requirements for information by higher authority are constantly changing.

Program managers speak at length on the need to instill confidence in superiors. This confidence is a foundation of rapport with superiors which, in turn, is one of the main sources of the program manager's authority. When it is obvious to functional managers supporting the program that the program manager has this rapport with his superiors, he will not need to rely as much on formal authority. One of the ways this confidence can be instilled is by demonstrating a knowledge of the program in the widest context. Knowledge of the program must embrace the threat, the direction in which the threat is evolving, other systems in the inventory which address the threat, program schedules, costs, technology--in short, everything important about the program.

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*David I. Cleland and William R. King, Systems Analysis and Project Management, McGraw-Hill Book Company, 1968, p. 239.

The Pentagon Participants

The major occasions when requirements, plans, and approval come together--the interface between the Service and OSD--are the reviews and decisions made by the SECDEF at three critical points in the life of a major system:

FUNCTIONAL RESPONSIBILITIES IN THE PROCESS OF ACQUIRING MAJOR WEAPON SYSTEMS

	CONCEPTUAL PHASE	PROGRAM DECISION	VALIDATION PHASE	RATIFICATION DECISION	FULL-SCALE DEVELOPMENT	PRODUCTION DECISION	PRODUCTION	DEPLOYMENT
SECDEF	X	●	X	●	X	●	X	X
SERVICE	●		●		●		●	●

● Primary Responsibility
X Monitoring Responsibility

The SECDEF makes the three key system decisions (the Program, Ratification, and Production Decisions) by choosing among alternatives posed in the Development Concept Paper (DCP) and in updated versions of this document. He also obtains the recommendations of the Defense Systems Acquisition Review Council (DSARC) to assist him in making his decision.

The DCP is the primary development program management document in OSD. It summarizes the essential arguments which the SECDEF must consider in arriving at his decision whether to continue the program and, if continued, in what form and with what restraints. It is a document prepared by

the Service and coordinated among all interested parties in the Services and OSD by the Office of the Director of Defense Research and Engineering (ODDR&E). Program managers are usually responsible for inputs to the document, and for its preparation and coordination within their Service organizations.

The DCP approved by the SECDEF will identify the limits or conditions that accompany his decision. It will also identify key program characteristics, the expected achievement of which formed the basis for his decision. These are the thresholds, or operating limits of cost, schedule, and performance which cannot be changed or violated without SECDEF approval. These thresholds require the Service to initiate a later SECDEF program review if the limits are likely to be exceeded. Since the program manager will be the first to know that these limits may be exceeded, he must assume a special burden to be sure that his Service authority is informed of all the pertinent facts and projected results.

The DSARC, which is the vehicle for OSD's review of the program being recommended by the Service, provides a major input to the Secretary. The DSARC is composed of the Director of Defense Research and Engineering, the Assistant Secretary of Defense (Installations and Logistics), the Assistant Secretary of Defense (Comptroller), and the Assistant Secretary of Defense (Systems Analysis). The Deputy SECDEF often attends these meetings.

A word of caution is appropriate. The life cycle of a system appears in the preceding chart to be laid out in nice, orderly steps. These steps may seem to be a one-two-three progression in which everything is settled before one proceeds to the next step. If weapon system developments were so orderly, there would not

be much of a management decision involved in deciding to proceed further. What drives the process is that decisions to proceed, or to stop, or to change direction, must be made with incomplete facts. Decisions must be made in situations where there are differences of opinion on things still not definitely established. Moreover, it may be decided that some steps in the sequence should be omitted entirely or, in rare cases, that two steps should be pursued concurrently to compress the time to deployment. What is important, however, is that, in making such a decision, SECDEF requires that he be informed of the potential consequences. He also requires a choice of feasible alternatives--alternatives which have been studied, shaken down, and evaluated from every important viewpoint. The program manager's role in this process is to ensure that all the feasible alternatives have been uncovered and provided to the Service for presentation to SECDEF.

CHAPTER TWO

PLANNING AND MANAGING FOR RISK AND UNCERTAINTY

Program Balance

Program balance is the product of a conscious recognition that there is an inescapable interplay among the three basic program elements of technical performance, time, and cost. It is a product of an awareness that we cannot talk about what we want without also talking about when we want it and how much we can afford to spend on it. Program balance also involves an awareness that the balance which is struck at the beginning of the program seldom can be maintained throughout the development. New facts, new technology, new threats, unexpected costs--all upset the old balance and require a new balance to be struck.

For the most part, techniques to establish and maintain program balance are the techniques of dealing with risk--the identification and evaluation of the risks, the selection among alternative risks, and the plan to avoid or reduce risk. By risk, we mean the chance of being unable to obtain what we want, when we want it, for the amount we want to spend on it. Most especially, we are talking about variations in the total risk arising out of adjustments in our objectives for performance, time, and cost. We are talking about the selection of the best alternative among the elements of risk--all things considered.

System Requirements

> The concept that requirements can be written as a statement of need that is independent of the means to satisfy the need is unsound. It leads

> to requirements being stated either in terms of rigid, immutable desires or in terms of things, not capabilities. The result has been inflexible requirement statements that make no provision for changes in threat, technology, or tactics; inhibit initiative and imagination in development; and often result in costly contract changes and overruns.*

The process of weapon system acquisition, alluded to briefly in Chapter One, implies something very different from this concept. The original DCP and its updating at each critical decision point of the program necessarily imply an unfolding of system requirements which are changing as more is known about the program. In each of the DCP actions, the SECDEF establishes thresholds for key program characteristics of performance, schedule, and cost. He requires prompt notice if any of these limits will not be met. The reason, as noted earlier, is that these key characteristics--what, when, and at what cost--individually and together form the bases for each decision to proceed. If any of these expected values does not materialize in fact, a different system may be wanted or perhaps even no system at all. Because these characteristics are at the very heart of a program decision, they cannot be changed by anyone except the Secretary. The point, however, is not that they cannot be changed. The point is that any change in these significant requirements and limits involves another look at the total system to answer the question: Is the system still wanted? Or is there another and, in the new circumstances, a preferred alternative?

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*Defense Science Board Task Force on R&D Management, Final Report on Systems Acquisition, ODDR&E, July 31, 1969, p. 4.

The consequences of failure to reexamine a program have been described in these terms:

> We have come to a time when meeting certain targets seems to have become more important than producing a satisfactory system... I know of a number of cases where the pressure on prediction has been so great that the Project Manager was forced to destroy the possibility of having a good system, because he was not allowed to adjust what he was doing to the real world; otherwise he would have been sufficiently far off prediction in one or another dimension that the project would have been cancelled. We fell between two stools: We got a system which was only approximately what we wanted and the system failed to meet the prediction. Similarly, we also have not had the sense to cancel something, which met the predictions, but was no damn good.*

In a practical sense, the key characteristics approved by the SECDEF and spelled out in the DCP become program objectives for the Service and the program manager. There is an inclination to view these characteristics as sacrosanct, particulary because failure to achieve them may be thought to threaten the program's continuation. That view is shortsighted. Some changes in key characteristics may be so obviously advantageous that they would be readily approved. For example, a modest delay in schedule and a minor added cost might allow an exploitation of new technology, possibly resulting in a significant improvement in operational performance. The same program revisions might also permit a more sequential scheduling of risky development steps. This could substantially improve the likelihood of achieving performance goals. A much more delicate situation arises when the program manager decides that one or more of these characteristics cannot be achieved at all or achieved only if another is sacrificed. Program

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*Robert A. Frosch, "The Emerging Shape of Policies for the Acquisition of Major Systems," Naval Engineers Journal, August 1969, p. 22.

cancellation or an extended stretch-out could be the consequence of this disclosure. The program manager may be under considerable pressure then to view things more optimistically. Higher authority, in some cases the Service Secretary--but not the program manager--must decide how optimistically a given situation shall be viewed.

Trade-Offs

The program manager cannot change the key program characteristics specified in the DCP. But his role in the acquisition process makes him the one person who knows best what beneficial trade-offs are possible during any stage of the program. As a consequence, the program manager is charged with ensuring that the responsible Service authority receives the information required to evaluate advantageous trade-offs as early as possible--and as often as necessary.

Another way of looking at program balance is to see it as trade-off analyses and decisions at two different levels and from two different perspectives: at the OSD level; and at the program manager's level, as an agent of the Service.

At the OSD level, the overriding objective of system acquisition is to field a system which achieves the right balance of operational effectiveness and total program cost. That is to say, what is sought is a system whose performance, scheduled availability, and total program cost represent the best balance of requirements and resources. That system is not necessarily the lowest cost system satisfying minimum operational requirements. The desired balance reflects consideration of the value of any improved or degraded performance or schedule characteristics--its worth in terms of benefit and cost. The specified key

program characteristics represent a decision where this balance is established from the broad perspective of an overview of DoD-wide program activities.

Subject to the constraints of the specified key program characteristics, there is a whole world of trade-off decisions to be made on other desired characteristics specified by the user. The program manager and the user must continually balance program funds, schedules, and the desired characteristics of subsystem performance. These trade-off decisions are a continuing process throughout the program as new developments and unexpected difficulties force the objectives to be reconsidered again and again. The program manager's objective is to field a system meeting the specified and the desired characteristics at the lowest total cost--and certainly at no more than the approved program cost.

As trade-offs are being considered during the program's evolution, and especially when unanticipated technical problems are encountered in the development phase, it may become evident to the program manager that some of the system requirements and limitations may be forcing trade-off decisions to suboptimal values. It may be evident that a better balance of system operational effectiveness and life cycle cost would be obtained by relaxing one or more of the constraints on key program characteristics instead of limiting the range of available trade-offs.

That is to say, from the program manager's perspective of one program, he may see that a relaxation of one or more constraints--which would be advantageous to his program--would probably also be acceptable to OSD when viewed from the broader perspective of DoD-wide interests. He may believe that the best program, all things considered, should be different from that approved by the SECDEF. In

these circumstances, the program manager must trigger the actions required for reexamination of program objectives. To do otherwise would be to assume incorrectly that sub-optimization is a policy goal.

Planning

The objectives and importance of planning in defense management are much the same as in industry.

> After all has been said and done about systems to control engineering costs and performance after the decision is made to embark on a project, it is the project plan prepared before starting the work that determines to a major extent the outcome of a project in terms of time, costs, and technical performance.
>
> Almost universally, there has been a lack of realization that, once a project plan is accepted, the die is cast. Further action can help to steer the course of the project and possibly conduct a rescue from disaster, but the road sign to the disaster point was erected when the project plan was written. But why was the plan faulty? The answer to this question is complex and not at all evident. There are many reasons for faulty project plans. Perhaps the outstanding cause is a lack of recognition of the importance of these plans... To be sound, a project plan must be produced through a systematic, detailed analysis that includes breakdown of the project by components, tasks, work packages, events (milestones), and approaches, rather than by the procedure known as SWAG (Systematic Wildly Assumed Guess).*

Planning is coming to grips with the hard details of program execution. It involves the examination and reexamination of the problems which are anticipated and the alternative ways in which these problems might be solved. Coming to grips with these details and

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*Peter C. Sandretto, The Economic Management of Research and Engineering, John Wiley & Sons, Inc., 1968, pp. 91, 105.

evaluating alternative approaches are basic steps in program formulation:

> The next consideration in developing the project plan is to determine the approach that should be taken to arrive at each component and the tasks involved in so doing... The procedure described above may appear arduous but is very necessary for producing a realistic project plan that will result in the best project at the lowest development cost and in the shortest time. The engineer or scientist must do his work over and over, taking into account every possible alternative solution. Not until three separate solutions (complete to necessary breakdown levels), at a minimum have been produced and compared can it be said that there exists a project plan in which management can place its trust. Only then can the plan be relied on not to place... finances in jeopardy.*

Planning Essentials

Department of Defense management policy on planning establishes basic objectives which are expected to guide the planning process and channel the plans. The main policy objective of defense program planning is to maintain a balance between dollar commitments and program risks. Its objective may be described as limiting the amount of resources committed to the program in the event that the results of development efforts require substantial redirection--or even program cancellation. The technique for obtaining this balance embraces five interrelated planning activities which are discussed in turn:

- Assess the risk implicit in alternative subsystem and system development concepts. Avoid alternatives involving low probabilities of success. Reassess risks periodically during the development program.

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*Ibid., p. 106.

- Reduce concurrency in risky situations to the maximum extent possible.
- Demonstrate mastery of high risk elements before proceeding into successive program phases.
- Control changes and be sure that all of the schedule and cost implications of a proposed change have been evaluated.
- Plan for unknowns.

Assessing Risk

Although risk assessment may not be formally addressed in a system design, it cannot be ignored. The selection from among alternative elements that make up a system necessarily involves at least an implicit estimate by the designer of the likelihood that one set of elements will result in more or less chance of success than another.

> Inherently, the risk of failure to meet objectives shadows all design and development programs. Yet, because it is a negative aspect, the incidence of risk is quite often overlooked in the glare of optimism. Or, even where it is not ignored completely, it may be appraised but not deeply enough, or perhaps not often enough to serve as a significant input for decision-making.*

What is perhaps new in defense policy is emphasis on identification of and insistence on formal analysis (explicit estimates) of the risks associated with different alternatives. The concept of risk assessment is made more complicated by the fact that the lesser risk may not be the optimum choice. Weapon system development extends over a long period--generally not less than

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*James R. Polski, "Managing Risks for More Effective Program Control," Cleland and King, _op. cit._, p. 356. Reprinted from General Electric Company, Missile and Space Division, _Aerospace Management_, Vol. 1, No. 1, Spring, 1966.

three to five years. Several more years usually elapse between the production decision and deployment. The system should not be obsolete when fielded. In many cases, it must push against the boundaries of today's technology if it is not to be obsolete in tomorrow's environment; this implies taking more and not less risk.

Risk assessment in this context is a decision-making tool. It is an estimate of the probabilities of success or failure associated with alternative plans. It is also a measure of the probability of meeting specified performance, schedule, or cost goals associated with a specific plan, and the sensitivity of this probability to changes in defined parameters. What, for example, is the range of probabilities associated with costs, given a defined set of technical performance and schedule requirements? What are the schedule and cost implications of less ambitious performance requirements--and the consequent elimination of one or more high risk system elements? What we are really talking about is a set of curves displaying the probability of certain consequences given one and another set of technical performance, schedule, and cost objectives.*

As a decision-making tool, the assessment of risk is, then, an essential factor in the decision process of selecting one design alternative over another. It is also essential in deciding whether to pursue a back-up development program to improve an unacceptably low probability of success in some critical subsystem element. Further, because risky designs may be dictated by overstated requirements, risk assessment also plays an important role in the determination of system characteristics and in the initial program decision.

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*Some techniques for risk analysis are discussed in Mr. Polski's article cited above and in Richard M. Anderson's, "Handling Risk in Defense Contracting," Harvard Business Review, July-August 1969, pp. 90-98.

Risk assessment is also a planning device. It embraces a plan for the development and test program that will resolve uncertainty in identified areas of major risk. It also embraces a control system to track and measure progress toward the resolution of uncertainty--to measure the reduction of risk according to plan. As with any other planning device, risk assessment is not a one-shot activity. The considerations implicit in the initial program decision must be reexamined throughout the development program. Alternatives, seemingly less attractive initially, may become better choices as development discloses more hard facts. Back-up programs in certain areas may no longer be the best investment of scarce resources as unanticipated problems are encountered in other areas. Program characteristics may have to be reconsidered as new data show that the overall risk inherent in an approved program was underestimated.

Reducing Concurrency

Conceptually, concurrency and risk reduction are closely related. By concurrency, we mean overlapping program phases, such as undertaking full-scale development before the conceptual phase has been completed, or undertaking production before development is completed. Concurrency, in this formal sense of overlapping major program phases, is risky business. While it may reduce the time span from concept to deployment, it involves a commitment to incurring substantial costs which may be wasteful in the event of program cancellation or redirection. As a matter of policy, this kind of concurrency is to be avoided and will be approved by SECDEF only in rare instances.

There is another kind of activity that is sometimes called concurrency. It embraces those steps in a

development process which permit an orderly transition from one phase to the next. For example, long lead time materials may have to be ordered in advance if there is not going to be an unbearable delay in the transition from development to production. In situations like these, program planning is aimed at steering a course between delay and waste. Risk assessment is a means of estimating the amount of potential waste, and the probability that the waste will occur. It would be best to view this kind of concurrency as something to be avoided in proportion to the degree of risk involved. The question then is: How much risk is there, and should or must that risk be chanced?

It is difficult sometimes to distinguish concurrency in the formal sense from normal program progression. What looks like concurrency may be an integral part of both a previous phase and a successive phase. Is a preproduction model for test the beginning of production or the end of development? Is the fabrication of the preproduction model on hard tooling an essential part of the development testing? If it is, some production tooling will have to be ordered and made before development is completed. The distinction is more than just one of degree. Concurrency in the formal sense implies a full-scale initiation of work in a successive phase when it is evident that the necessary work in the previous phase has not been completed. That is not permitted. Concurrency in the loose sense is a product of orderly, careful planning. That is not only permitted, it is essential.

Reducing Risk

Each program must be treated as an individual case, but there are two general rules that can be applied to all. First, the development program schedule can be examined to see if any costly work which might be significantly affected by other work can be rescheduled to a

later start without slipping the program completion date. Second, the impact on the risk of wasted work of slipping the total program schedule can be examined. It is possible that slippage of the scheduled date for operational capability will more than pay for itself by reducing the risk of costly rework caused by concurrency. This is especially likely in the scheduling of initial production activities. Production costs are usually many times greater than development costs and involve commitments for a wide variety of long lead time items. Changes in the later stages of development are likely to have a substantial impact on production commitments. Delaying commitments for production until successful development has been fully demonstrated is likely to have a large payoff in total program cost.

Other ways of reducing risk also require tailoring to specific programs, but we can identify approaches that should be examined:

- Practical trade-offs between operating requirements and engineering design.
- Avoidance of high risk alternatives.
- Hardware and system proofing to demonstrate that risk has been reduced to a reasonable level.
- Back-up programs for high risk elements of the system.
- Concentration of effort early in high risk areas.
- Program scheduling so that uncertainties are resolved before putting resources into easy parts of the system or into the full program.

Milestoning

Milestones are events whose successful accomplishment signifies completion of some key, meaningful, and measurable aspects of development activities. In terms

of risk assessment, they represent the accomplishment of some aspect of the program by proving that a significant objective--an event with an identified possibility of failure--has been attained. The remaining program risk is reduced. In some other context, milestones may represent the start of something and, because they are usually associated with estimated dates, they may provide some measure of adherence to schedules. In the context of the essentials of program planning, however, they represent the accomplishment of work; schedule is secondary to the fact that progress has been proved objectively.

Objectivity is an essential quality of milestones. Milestones are not elastic events which can be stretched by emotional rhetoric or tailored by fancy to fit the situation. They are events which have been programmed in advance. They are events whose successful accomplishment will be measurably hard and demonstrable evidence of progress toward the program goals. Milestone planning necessarily implies, therefore, that a test and evaluation program is tailored to the milestone demonstrations. If milestones are not to become elastic events, test routines and standards must be spelled out in advance. For example, first flight of a new airplane is not a meaningful event without defining the weight, speed, altitude, and other aspects that describe the accomplishment of an established, definite, measurable objective.

Key milestones play an important part in DSARC reviews and SECDEF decisions to proceed into successive program phases. They answer the question: Has enough meaningful progress been made to justify increasing the government's financial commitment? The decision to proceed can be based either on wishful thinking or on demonstrable accomplishment. It is not a recent concept of management to discount wishful thinking and to insist on demonstrated achievement:

> When luck is even, daring is rendered more reliable by intelligence and the sense of superiority it gives; intelligence trusts less to hope, the strength of men who have no other resource, than to judgment based on facts, from which is derived sounder foresight.*

The use of milestones in planning and controlling major weapon system acquisitions is not new. Milestones--events of significance--occur in every program and are used by decision makers at various levels. A program manager will use a large number of schedule milestones to manage his program.

Key milestones--events of special significance--are of interest to higher levels of decision makers because they are selected and used in a new way. They are used to provide progressive assessment of the reduction of risk, and to see that commitments are based on actual accomplishments, not planned accomplishments. In this manner, decisions which commit funds or reduce available program options will be based on events, and not on calendar dates. Time is made a variable and, when appropriate, contract provisions will be written to provide alternatives to the government in the event milestones are not met.

Key milestones--risk assessment milestones--have two basic purposes:

- In planning a program--to structure the program so that progressive commitments are made only when justified by the remaining level of program risk.

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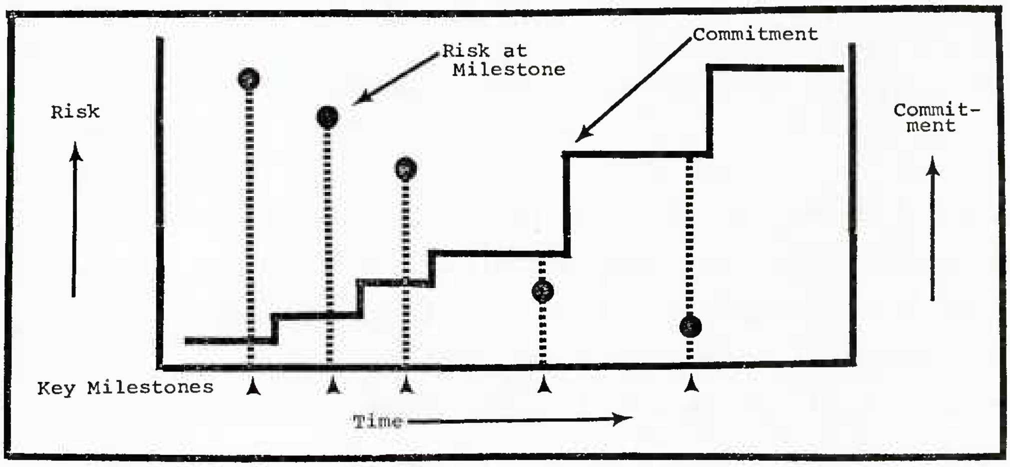
*From Thucydides (471-400 B.C.), The Peloponnesian Wars, quoted in Specialists and Generalists, op. cit., p. 3.

- In managing a program--to assure that the premises on which program commitments were originally planned have been validated, or proven, before additional commitments are made.

These purposes can be illustrated in a simple way:



<u>Changes</u>

Change control is based on two related precepts:

- Let a good thing alone.
- What looks like a pussy cat may turn into a tiger.

The first precept stems from an awareness of the real world of development:

> Anyone who has ever done a development, or a design (as opposed to setting up a management system for doing so) is well aware of the fact that the real world proceeds by a kind of feed-back iterative process that looks more like a helix than like a line. That is to say; you do A, then B, then C, then you look at C and go back and change part of A again, and that causes you to fiddle with B and perhaps bring in a B prime that you bounce against C, and then go back to A and then jump to D, so that there has to be continual adjustment, going back and forth so that the system is adjusted to itself and to its end objectives as it changes and as the design or development proceeds.*

Changes which require adjusting parts of the system whose development has been completed--and especially any fiddling with elements of large risk that have been successfully surmounted and proved by tests--disturb the whole structure. A minor change looking toward a modest improvement may have an impact on all kinds of work completed, in-process, and anticipated. The magnitude of these effects is hard to estimate, but must be considered.

The second precept stems from the first. Because the magnitude and range of effects are hard to estimate, an innocent-looking change may play havoc with cost and schedule objectives. Major redesign may be required, new elements of risk are introduced, and risks previously reduced or eliminated may be restored. The change could wreck the program.

Change control implies these rules:

- An initial predisposition against changes. If in doubt, don't make the change.

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*Robert A. Frosch, op. cit., p. 21.

- A detailed analysis of the direct and the likely impact of a change on all three program characteristics: performance, schedule, and cost--especially the last.
- A continuing predisposition against change after the analysis is completed. The probability is that things will turn out much worse than the analysis has predicted.

These rules have been followed by a number of military program managers who said that their change policy was to have no changes at all--and then back down from there only when there was overwhelming and convincing justification for, and evaluation of, proposed changes.

Reckoning With Unknowns

Planning for unknowns is the last of the essentials of program planning. Unknowns come in two varieties: anticipated unknowns (or known-unknowns) and unanticipated unknowns (or unknown-unknowns). The latter are also called "unk-unks".* Planning for anticipated unknowns is the basic substance of risk analysis and plans for orderly risk reduction. Probability analysis as a tool in planning necessarily implies recognition that there is a given probability (however small) of failing to achieve some objective in the system development. This recognition should in turn dictate that some thought be given to the consequences of a failure--a

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*The source of this nomenclature is the reports of the Aerospace Technical Council of the Aerospace Industries Association (AIA), Essential Technical Steps and Related Uncertainties in DoD Weapon Systems Development. There are four reports in this series: Phase I, May 1968; Phase II, September 1968; Phase III, October 1969; and Phase IV, December 1970. All four contain a wealth of information and insight into the development process from an industry view.

failure either to meet a performance objective or a scheduled target for some system element.

The possibility of failing to meet a performance objective during development should generate a "what if?" plan. The alternative may be program cancellation. It may be something less, but still acceptable, in the way of system capability.

The possibility of failing to meet a schedule target can be treated by recognizing that some slippage, somewhere, sometime is inevitable. Consequently, the total system schedule must allow some breathing room--some slack time--to accommodate some slippage. The program must not be so tightly scheduled that a slippage has an unavoidable and devastating effect on other connected paths, and a consequently devastating effect on program costs or deployment schedules. Building some slack into a program is hard to do, especially when external pressures usually demand acceleration, but slack is absolutely essential.

Planning for the unk-unks is conceptually disturbing. How can one plan for an unknown eventuality? It is especially troublesome because the AIA study of uncertainties associated with specific programs identified many problems which were revealed only during the later phases of system assembly and test:

> Problems brought to light in this period tend to show the need for significant changes in performance specification at end item and system levels, usually requiring revision of design, with, in many cases, adverse program effects.*

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*Ibid., Phase I Report, p. 8.

The implications for system program plans are obvious: schedule slippages and added, unexpected costs are all but inevitable in these later phases--time and money need to be squirreled away in each of the major program phases for the rainy day that is certainly coming. This essential slack is easiest to hide when it is built into the early program plans.

A further implication is obvious: subsystem hardware tests must be pushed upstream to resolve as much uncertainty as possible in subsystem elements before the program is besieged with system problems. A good risk analysis and risk reduction program plan already embrace this need.

CHAPTER THREE

INDUSTRY INTERFACE

Importance

The term "industry interface" is not merely an elegant expression for contracting, although it includes contracting. It is something more. It suggests some feeling for the relationships between government and defense industry--something of the setting in which the system acquisition process takes place. It also implies an understanding of some of the things which influence and motivate industry. The interface with industry has peculiar relevance for military program managers. By far the larger part of total program acquisition funds will be spent through industry sources. Program planning and control activities will be largely dependent on industry inputs. Some program managers have had very little direct contact with industry. Given the reliance on industry's efforts, much of a program manager's time and attention will have to be devoted to problems in an environment which may be new to him.

As one program manager notes:

> You are deep in contractor problems from the beginning. If you are going to do your job right, you have to know your major contractors--their history, organization, people, and the way they do business. To understand a contractor, you have to know something about the industry he is a part of--its growth or decline, and its problems. And to understand an industry, you have to know something about what motivates business in general. Industry goes to great lengths to learn everything it can about its customer--the government. A program manager should do no less in learning about his major suppliers.

The kind of information needed embraces such things as areas of market interest, the number of suppliers and trends toward concentration, interest in seeking primarily commercial or government work, backlog of commercial and government work, relationships with parent organizations, recent management changes and reasons for the changes, and recent organizational changes. Trade journals are a useful source for this information. The procurement office can furnish additional information. The contract administration people in the field who have cognizance of the contractor's plant can provide a lot of insight into recent developments and trends that are part of the intelligence needed to understand a contractor.

An Unusual Market Place

The weapon system market place is not the same thing as the traditional market implicit in a private enterprise system. The traditional market place is one teeming with buyers and sellers, each striving to make the best bargain he can. Supply and demand determine prices. Sellers vie with one another to attract buyers with new wares, and buyers will substitute other items if they cannot satisfy their preferred requirements at what they consider a fair price.

The weapon system market place is not the traditional market for one obvious reason. There is only one buyer--the government. There may be many users, foreign and domestic, but there is only one buyer. There are other differences which are at least partly attributable to there being only one buyer. There are not many sellers of the highly sophisticated equipments which make up today's weapon systems. There may be only one seller, or a few at most, for a specific system. These sellers are largely a dedicated industry. That is, they exist

primarily to satisfy one buyer's requirements for goods and services which they cannot sell elsewhere. The sellers need the buyer and will compete fiercely for his business; but the buyer also needs the sellers. If the buyer does not conserve his suppliers, he may find no one who can satisfy a present or future requirement. In an important sense, there is a reversal of roles compared with the traditional market. There the sellers attract buyers; in the weapon system market place, the buyer attracts the sellers.

One consequence of the fact that there is only one buyer and only a few sellers is that there is a limited number of competitors for major programs. The competition itself is also different. In the traditional market, a sale lost one day may be captured the next. But in the weapon system market place, the next sale may be years in the future. The competition is often for nothing less than survival as a source in an area of established capability.

> For its part, industry feels it must employ the competitive tactics called for by the environment of the defense marketplace. A contractor who does a thorough and realistic job of analyzing and pricing the technical risks inherent in his proposed approach to systems development knows that he is likely to find himself the loser to a more optimistic competitor. In brief, in the environment of a buyer's market, optimism seems essential to survival. This inevitably is a more compelling motivation to the seller than risk minimization through objective realism in his proposals, the probable end result of which is losing business.*

This auction of optimism can be controlled only by evident skepticism on the part of the program office toward unsupported assertions.

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*National Security Industrial Association (NSIA), Defense Acquisition Study, Washington, D. C., 1970, p. 4.

In addition to limited competition at the beginning of a program, there is almost no hope of obtaining competition or changing sources once a source is selected and the program is under way. The selected source very quickly acquires people and experience--and the government acquires a sunk cost (both money and time) in the people, the experience, tools, and equipment--that effectively precludes changing sources. One observer described this situation vividly:

> Buyer and seller are locked together in a relationship analogous to bilateral monopoly for the life of the program, and they must deal with each other on a bargaining basis.*

This locking together of the contractor and the Service highlights a major difference between the traditional and weapon system markets. In the traditional market, the seller invests in the product development and brings finished goods to entice buyers. The buyer is not an investor. In the weapon system market place, the Service pays for the product development of weapon systems because of the cost and risks involved--it is both the buyer and the investor. The implication of this dual role is that the Service thereby purchases the right to exercise more control over its weapon systems contractors than is usually attributable to buyers.

Contractor Motivation

The long-term motivation of contractors is survival. In the long-term, survival requires profit. There must be the prospect of future earnings to obtain loans. There

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*Frederick M. Scherer, The Weapons Acquisition Process: Economic Incentives, Harvard University, 1964, p. 2. This and a companion study, Merton J. Peck and Frederick M. Scherer, The Weapons Acquisition Process: An Economic Analysis, Harvard University, 1962, are essential background material in a study of the acquisition process.

must be earnings to pay interest on present indebtedness and to retire loans. There must be additional earnings sufficient to satisfy the stockholders, satisfaction which is obtained by dividends on their investments and a competitive appreciation in the value of the company's stock. Stockholders may be long-suffering in anticipation of better days to come, but sooner or later they expect satisfaction, or they go elsewhere with their money.

If a company must be profitable to survive, it must also survive if it is going to be profitable. If it cannot obtain business, it will not survive. In the short-term, therefore, the emphasis is on survival and growth. Profitability is much less important in the short-term. In the short-term, the company is focusing on entering new programs, ensuring its continued role in established programs, and seeking ways to expand its role in these programs. Customer satisfaction on established programs is important, since it determines both the continued role and the possibly expanded role of the company in the program. In the short-term, this customer satisfaction is more important than stockholder satisfaction. This means that in most situations a program manager cannot let himself be lulled into thinking that profit or the opportunity to earn an extra, incentive profit will motivate his contractors toward the objectives he seeks. His contractors are more likely to respond to his candid appraisals of their performance which communicate clearly his satisfaction or dissatisfaction with their efforts. This implies the need for personal involvement with the contractors' management people.

Studies of 12 weapon system acquisition programs in the period 1945-1960 clearly indicated that the way to satisfy the military customer was to emphasize weapon system performance. Maximizing technical excellence was more important than minimizing development time, and both

were much more important than minimizing cost.* The contractor's reputation would suffer most from failure to achieve technical goals; consequently, weapon system programs generally achieved the technical goals, but there were substantial variances in development time and even larger variances in meeting cost objectives.** This emphasis on technical goals at the expense primarily of program cost served both the short-term and long-term objectives of defense contractors. In the short-term, contractors were giving the customer what he wanted most. In the long-term, they were enchancing their technical reputation and increasing the scope and the depth of their technical resources. These increased technical resources would, in turn, improve the contractors' capabilities and enhance their chances of being selected for other weapon system development programs.

The importance of technical excellence to both the government and contractors is no less today than it was earlier. What is different today is defense management's insistence that technical excellence must not be pursued without also pursuing schedule and cost objectives.

This attention to schedule and cost objectives puts pressures on technical achievements that are not present when technical excellence is the only or dominant goal. Schedules and budgets must reflect the obvious (but often overlooked) fact that although technical achievements can be scheduled and good management can help to keep them on schedule, they are not achieved on demand or by edict. The pressures which cost and schedule objectives put on technical achievement sometimes result in efforts to achieve savings at the expense of essential technical

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*Peck and Scherer, op. cit., pp. 288-298.

**Ibid., p. 429.

steps. The program manager must be wary of suggestions that certain tests can be eliminated or documentation delayed in the name of savings. This attitude of wariness is appropriate whether the suggestions come from contractors or from his own staff.

Contracting

Contracting is a functional expertise, like many other functional activities which contribute to successful program execution. Yet, it is something special for the program manager. Most of the program output will be obtained through industry sources, and contracting is the means of achieving arrangements with these sources. If mistakes are made, they are longer-lasting and less amenable to simple correction than mistakes in other functional areas. Moreover, the art of contracting is particularly dependent--if it is to be done right--on an understanding of the program's requirements. Only someone intimately familiar with present and future program plans can communicate this understanding. That someone should be the program manager. It must be the program manager if he wants the right results.

The objective of the contracting process is to get the best source working for the program under the best arrangement. Every program manager and every contracting officer ought to agree on this motherhood statement. More important, they ought to agree on what logically follows from it--that competition is a tool for identifying the best source and that the contract is a vehicle for defining the best arrangements.

It would be unrealistic, however, not to acknowledge that there is a predisposition to conflict between the technical people in the program and the contracting people. To technical people, the contracting officer is often viewed

as a policeman waving his book of unintelligible rules, insisting on competition for its own sake, unwilling to accept technical judgments on the sources which should be used, emphasizing price to the exclusion of any other consideration, and generally making more work and slowing things down. To contracting people, the technical man is often viewed as emphasizing technical quality to the exclusion of everything else, unwilling to consider contractor past performance, always behind schedule and trying to make it up with a quick contract award, disdainful of lead time realities, wedded to his contractor, unmindful of laws and regulations, and generally going too fast and taking too many shortcuts. Both have experienced one or many occasions of frustration with the other, when their expressed views were only a pale reflection of their innermost thoughts.

Type of Contract

There are essentially two basic types of contracts: fixed price and cost-reimbursement. There is an endless variety of pricing arrangements which shade toward one or the other. This variety makes it difficult (and perhaps a little silly) to talk about the effect of one or another type but some differences are clear at the extremes.

The characteristic of a fixed-price contract is that there is a legal commitment to deliver something--hardware, a report, or a service--no matter what the actual cost of performance may be. If the cost of performance exceeds the contract price, the contractor suffers a loss. Theoretically at least, the loss may grow larger and larger as the contractor strives to deliver what he has contracted to deliver. If the contractor fails to deliver, he will be paid nothing for the effort made. Indeed, in its usual form, a fixed-price contract gives the government

the right to procure from another source and to collect from the unsuccessful contractor any added costs.

The characteristic of a cost-reimbursement contract is that the contractor's legal commitment is to work at what he is supposed to do, but only if the government reimburses him for the costs he incurs in trying. If the government stops paying for the work, the contractor has no further obligation and there is no liability for costs which may be incurred by the government in going to another source.

The differences between these two types of contracts are very marked. Equally marked differences are evident in their impact on competition and on the pressures they put on the contractor and the program. A feeling for the consequences of these differences is important. Three facts must be kept in mind, however. First, the more extreme form of fixed-price contract is rarely used in the larger and more important contracts entered into in the early phases of the weapon system acquisition process. Second, the way in which a contract is administered--changes, for example--can shade a fixed-price type contract toward a cost-reimbursement arrangement. Third, the form of the contract is only one factor in any given situation--other factors (such as the contractor's current work load and future prospects) may be far more important in their effect on the contractor.

- A dollar amount on a cost-reimbursement contract is not a price. It is only an estimate. The price will be what it actually costs to do the work, and the program manager must manage the contract and budget with that fact in mind.

- If the contractor will be reimbursed for his costs, as contrasted with what he estimates, there is a tendency to beat the competition by underestimating cost and overestimating

what can be done for those dollars. The estimates quoted by contractors are not a sound basis for selecting one over another in a competitive situation. If the contractor will be held to a fixed price, no matter what the costs, there is a built-in restraint on puffery and the prices quoted have some validity for source selection.

- If the contractor will be reimbursed what it costs, he is likely to accept guidance, direction, and redirection by the program personnel. It will cost him nothing to be cooperative, although the result may be a cost overrun on his earlier estimate. If a contractor will be held to a fixed-price, he will resist this direction. He will seek formal change notices to adjust his price for the new work being thrust upon him.

Among the host of errors that can be made in contracting, the one with the greatest potential for generating problems is selection of the wrong type of contract. Although other factors may cause an entirely different response, a fixed-price contract motivates a contractor to do a minimum job, to do the least work that must be done, to choose the lowest cost solutions to problems that may arise. A fixed-price contract drives a contractor that way because the government is telling him that he will be paid some fixed sum for the results described in the contract. This may be exactly what the government wants to tell a contractor in certain circumstances. But if the government wants and expects something more, the contract should reflect that. Perhaps you might expect the contractor to do what benefits the government without a corresponding benefit to the company. But it is unreasonable to assume that the contractor should do anything which is detrimental to his own interests. A cost-reimbursement contract overcomes this problem but not without substituting a different problem. If the government will pay the actual costs incurred by the contractor, what is the incentive to keep costs as low as possible?

The selection of the right type of contract is influenced by the Service-contractor roles implicit in each type. The program office looks a little silly if it complains that the contractor is uncooperative with respect to suggestions for technical improvements when the contract is a fixed-price contract with all sorts of provisions fixing performance responsibility on the contractor. The cooperation sought by technical people in those circumstances is akin to a friendly assist to the contractor on his way to the poorhouse. If program office or government laboratory personnel are going to play a significant role in deciding how the contractor will go about his work, and the contract does not reflect that fact, there undoubtedly will be conflicts.

Competition

The main advantage to the government of competition is the advantage of motivating a contractor to not inflate his estimate of costs. The possibility that another contractor may be able to satisfy the government's requirement at a lower price is a powerful incentive to match or beat the competition. Another significant advantage of competition to the government is in motivating design improvement--to beat the competition with a better product. The better product may cost more: what really beats the competition is better value for comparable dollars. Competition encourages innovation and cost control by contractors.

Competition and type of contract are different subjects, but they are related. Competition is a problem in the environment of much of the weapon system development process. If a source selection is made early in the development cycle, the type of contract presents an enigma. If a fixed-price contract is used, the contractor assumes the risk involved in proposing firm prices for something not yet

developed. If a cost-reimbursement contract is used, contractors are likely to underestimate costs and overestimate what can be achieved in their desire to obtain the contract award. In addition, at this early stage, the government is unlikely to have a sound basis for an independent evaluation of cost estimates for either type of contract.

Competition on a fixed-price contract basis is desirable when the program office knows what it wants, has a design which it can describe, can write explicit specifications, and the work can be done largely without guidance from the program office. Some parts of the total program will meet these criteria. For these parts of the program, the best price will be obtained by fixed-price contracts, and their costs can be budgeted accurately. But when what is wanted is something new and different, when what is sought is really development rather than production, fixed-price contracting and price competition are too simplistic. The contract arrangements appropriate for any given situation can be determined only after a hard look at what is wanted and what is known about it--and with a realistic appraisal of the risks involved.

Knowledge and the risks involved in a development undertaking are not static. A contract form inappropriate at an early stage may become appropriate at some later stage. Contract arrangements can be, and should be, changed accordingly. But in the early stages, we are likely to know little; consequently, the risks are likely to be great.

> When you are dealing with development, procurement is not a way of buying something. It is a way of making arrangements to get something done.... In the development situation there is <u>no object</u> to purchase, there is only an <u>objective</u> to purchase. There is <u>no</u> defined piece of hardware that can be priced in the same sense as we price a manufactured object. Nevertheless, in attempting

> to buy development we behave as if there really was such an object. We act as if the airplane that we had put a name to and specifications on, has in fact real characteristics and a defined real price.
>
> From an engineering point of view at the point in time at which we purchase development, there is no such object. We are only purchasing somebody's plans, somebody's objectives, somebody's proposal against a set of specifications that we think are what we want to buy. The specifications are made from a set of requirements that we think are what we want. If we actually had a definable object, definable in the sense that we could give precise description to what it was, and know that when we got it, it would work correctly and be what we wanted, then there would be no sense of entering a development project at all; we could simply go out and buy it.
>
> The whole point of a development process is to get something that we haven't got, something that we have never seen, and something which we don't really know can be produced.*

One way out of this dilemma is for the Service to sponsor competition until competing designs are developed to the point where fixed-price contracts can be entered into in a competitive environment for the balance of the program. This approach is called parallel development. Two or more contractors are sponsored until the Service can make a selection among competing designs and prices in a competitive environment. Parallel development is carried on until three conditions are satisfied. First, the contractors must know enough about their designs to assess accurately the risk they would be embracing in proposing to complete the program on a fixed-price basis. Second, the Service must know enough about the

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*Address by the Honorable Robert A. Frosch, Assistant Secretary of the Navy for Research and Development, at the Sixteenth Annual Institute on Government Contracts, George Washington University/Federal Bar Association, Washington, D. C., May 8, 1969.

designs to select the best alternative--price and all other factors considered. Third, the Service must be able to assess the risk being assumed by the contractors and independently determine that it is reasonable for the contractors to assume that degree of risk.

Sponsoring two or more contractors for parallel development is going to cost more in the early program stages. The cost of competing on that basis is usually too large for a company to undertake unless the government sponsors and pays for it. The additional expense may be recouped by obtaining lower prices in the later program phases than would be obtained in the absence of competition. Another benefit is the added assurance of a successful program because of the reduced risk implicit in parallel efforts. Competition can be sponsored at the system contractor level, among major subsystem elements, or at both levels. Whether it is advantageous to sponsor competition, and at what level of system work breakdown structure, are mostly matters of judgment. The decision--whether the benefits are worth the added cost of development--must turn on the facts in the specific program:

- The relative costs of development and production.

  The development costs to the point of a sound basis for contractor selection must be compared to the costs of anticipated production. If the development costs are relatively low, competition in development looking toward competitive pricing of production is more advantageous than it would be if development costs are relatively large.

- The pricing environment.

  If the item is one for which there is a substantial pricing history and there is confidence in the accuracy of cost estimates, competition is not needed as much as it is if the government would be dependent on contractor cost estimates for production.

- The technical, schedule, and cost risks.

  If the risk of failure is relatively large and the consequences costly, parallel development is advantageous as a planned reduction of risk.

To highlight the range of problems associated with competition and type of contract, we might suppose a situation where competition can be obtained, and a contract can be written holding the contractor to a high level of required performance on a fixed-price contract basis. It may seem that the program manager need not concern himself with questions about the reasonableness of these arrangements. After all, no one is forcing contractors to commit themselves. They could refuse to bid. The winning bidder should be assumed to know what he is doing. We must not lose sight of the fact, however, that successful completion of the work is the main objective--and cost or price is only one aspect of the program. A contractor may yield to the government's superior bargaining position and agree to a high risk development effort on a tight fixed-price basis because it may be "the only game in town". If the result of the arrangement were, in fact, to bankrupt the company before it had completed the work, the program manager would still have the same problem he started with--the problem of completing the development and production of an operational system. In addition, he would have acquired another problem--a schedule bind.

Perhaps the most important single point is that system contracting is a complicated subject. Every situation has its own unique problems. Experience begets a feel for the nuances which make the difference between rote application of rules and sensitive creativity. A program manager who has directed two defense programs sees it this way:

> One thing you must do is lock your technical people together with your lawyer and your contracting officer. A contract is a legal agreement. The lawyer and the contracts man find the weaknesses and the inconsistencies--they are trained to find the soft spots. They can focus business judgment on the procurement. But if they are going to be helpful they have to be in on the whole deal early and stay with it. Don't look on them as paper-pushers. They should be reading the specifications and requirements right along with the technical people. Their function is to tell you whether you can contract on the basis you have fashioned and whether you can enforce it if you are pushed. Similarly, the technical people should be reading the proposed contract right along with the lawyer. They have to live with the deal every day, and it had better make sense to them, too.

In a real sense, it all goes back to fundamentals. If the program manager, the technical people, the lawyer, and the contracting officer communicate with each other, the right contracting methods can be found. If they do not communicate the facts and the real intent, problems are inevitable.

Pick a Winner

The selection of the major system prime contractor is the single most momentous decision in the management of the program. A bad choice is a curse, a good choice is a blessing, and a mediocre choice means more work for the program manager. Every part of the program activity will be touched by the prime contractor: subcontract management for major subsystems, program budget forecasts, schedule compliance--everything. The benefit of his excellence or the debilitating effect of his incompetence will be evident everywhere and every day.

This being the most important single decision in the program operation, it may seem incongruous that the selection is taken out of the program manager's hands to be

made at a considerably higher level, perhaps even at the level of the SECDEF. It is not incongruous, however, if we consider the public interest involved in decisions of such dollar magnitude; and, whether incongruous or not, it is the general policy. The program manager may or may not play a formal role in the source selection process--that will depend on Service policy. But, whether or not he plays a role in the source selection process, and although he will not make the official selection, the program manager has a personal stake in the results. He can (and should) influence selection activities to protect his stake. A major opportunity is provided in supporting the selection process. He will do much--if not all--of the original staff work in proposing the evaluation criteria and developing the list of recommended sources to be solicited.

There are important ways in which the final results can be influenced by the program manager:

- The sources selected for conceptual studies will obtain program visibility that will enhance their position in later phases of the program. The framework for effective competition can be constructed in the selection of contractors for these studies. Good sources can be encouraged to become interested in the program and to stay interested. Persuasion may be essential if the program is not yet well established and there is a likelihood that it may be cancelled or stretched-out.

- The best people are not always assigned to source selection duties by the functional elements. The program manager should use his personal contacts to get the better people assigned. Command support should be solicited, if necessary.

- Program office personnel should be made available to participate in the source selection process even though they can hardly be spared from other duties. The

program manager will want to nominate someone from the program office as chairman of the Source Selection Evaluation Board, the group that performs the detailed evaluation of proposals. The outcome is too important to be left to others who will have less reason to care about the results.

- The factors which will be used in proposal evaluation--and the relative weighting of these factors--should be tailored to the requirements of the individual program. Items important to the management of the program must not be lost in a welter of technical minutia. Management factors are important and likely to be slighted at the expense of the program manager's future well being. He must see that the experience, ability, and authority of the program managers which the industry sources propose to assign to his program are carefully examined. This factor should be given significant weight in the evaluation process.

- Good system design is another factor likely to be overlooked in the evaluation process. The Evaluation Board forms into panels, and specialists will examine every subsystem element. The program manager will want to ensure that the Board also looks at the total system.

What is true of major formal source selection procedures is true also, in relative terms, for the smaller contracts where proposal evaluation and source selection are performed in the program office or by a supporting functional element. Although the processes are much less formal, the need to select the best is no less significant, and the use of appropriate criteria is no less important to the program manager. The magnitude of his potential headache is not necessarily proportional to the size of the contract. Moreover, a rigorous insistence on selection of contract sources by objective standards--rather than by subjective whim--will have a salutary effect on the climate for rational thought and action for both the program office and its contractors.

CHAPTER FOUR

TECHNICAL ACHIEVEMENT PROBLEMS

Putting Technical Achievement in Perspective

Given unlimited time and money, there are scarcely any problems of technical performance. Almost any technical problem which does not involve sorcery can be wrestled to the ground eventually or drowned in a sea of cash. If this is true, it also may be said that there are only problems of schedule or funds. There may be, however, one purely technical problem. That one is where the system fails to satisfy the user's requirements and is something the user neither needs nor wants. This situation could develop from an ambiguous statement of requirements, further compounded by inadequate coordination with the user on trade-off decisions. Even in this extreme case, however, added time and additional funds could solve the problem. You could even start all over again.

It is clear that technical performance (the product) cannot be isolated completely from time and money (the resources). Problems of technical performance, in general, will be manifested as resource problems. The technical problems addressed in this chapter are inextricably bound up with resource implications. This relationship should not be obscured by the fact that the problems are addressed as technical ones.

In one sense, problems of technical performance are the least of the program manager's worries. There is general agreement among experienced program managers that time is their greatest strain, even when the original plan was acknowledged to be reasonable. Time seems to evaporate mysteriously, and everything takes longer. The strain of

time is closely followed by dollars. Performance is their least troublesome concern because the developers--whether industry sources or government laboratories--concentrate on achieving performance. But in striving for performance, they tend to downgrade the importance of schedule and funds. The program manager is not likely to add much of anything to the program if he pursues the same objective everyone else is chasing. His contribution should be to focus attention on schedule and cost to maintain a balanced program.

Engineering Optimism

Optimism is not a trait peculiar to scientists and engineers. The problem is that engineering optimism easily reaches epidemic proportions. Nothing is impossible for talented designers and developers, and the greater the scientific and engineering challenge the more fun it is. This optimism is an essential ingredient of human progress. It is also an essential attribute if technical innovation is to be made in new weapon developments. On the other hand, optimism leads to an overestimate of the ease of doing something and a corresponding underestimate of the time and resources it will take. Management's problem is to keep the spirit alive to obtain the benefits but, at the same time, avoid the detrimental consequences of overoptimism. Engineering optimism is great--it is even essential--but someone has to administer the antidote if there is going to be program balance. The antidote is skepticism.

Skepticism is the second requisite of engineering management. Planning is the first. If planning is carried through in the detail and with the coordination that are essential, it will disclose what has to be done. Skepticism will probe the estimate of how simple it will be to do it. The searching question is: Just what makes you think the estimate or prediction is worth a tinker's dam? The obscuring smoke of optimism has to be dispelled sufficiently so

that the real basis of the estimate can be exposed. The estimate may be soundly based--but it may have emerged from someone's imagination. Persistence and insistence on full disclosure are absolutely vital. Two benefits can be expected from a searching inquiry: one is a lessening of overreaching technical sophistication; the other is a better program plan.

The problems associated with engineering optimism are especially murky in programs which are deemed to be "well within the state-of-the-art." These programs are represented to be simple stuff, hardly worth serious technical contemplation; off-the-shelf items--requiring only that someone put the pieces together, using today's technology. It usually doesn't work that way. Anyone who has assembled a set of stereo hi-fi systems--using off-the-shelf components--and then spent hours (or days) tracking down the sources of the hum and ear-shattering acoustic feedback knows better than that. In the Defense Department, some of the most highly publicized cases of cost growth involved programs that originally were thought to require simple technology and modest engineering skills. Don't believe it when an engineer says, "It's easy." Make sure he has thought about it. More important, take a close look at the test program which will demonstrate that it has been achieved so easily.

Engineering optimism also manifests itself in a single-path technical approach. It is economical and certainly attractive for that reason. It is also risky. Through risk analysis, the consequence of failure has to be examined together with the likelihood of failure. If there is a significant probability of failure, coupled with a potentially severe impact on the program plan, parallel development paths may be appropriate, no matter how

confident the engineer is that he can handle the job. Parallel development often can be undertaken at quite low levels of effort and chopped off when confidence in the success of the main-path effort has increased. This may appear to be wasteful. The money spent in this way is no more wasted, however, than life insurance premiums are wasted because one does not succeed in dying prematurely.

Another aspect of engineering optimism is a tendency to assume the adequacy of an engineering solution to a problem without verifying it before moving on to the next problem. Having sweated through the solution, it may seem to be pretty straightforward. The tendency is to assume that because it ought to work, it is going to work. Critical aspects of performance need to be demonstrated, and one cannot rely on the development engineer to check himself. A test and evaluation program has to be imposed on the development process--with guidance from the developer--but, nonetheless, imposed.

The problem of engineering optimism has its most upsetting impact when it results in changes that are introduced after satisfactory completion of component or subsystem development. It seems so simple to add a little something here or improve something there. Too often there is a totally insufficient analysis of the possible impact of the change on other parts of the system. There is too little attention given to the possibility that the change may invalidate previous test results. There is too little concern with the simple, functional solution and too much attraction in the more complicated, sophisticated solution. It is bad enough if optimism impedes program development, but it is much worse if it causes things that work satisfactorily to be replaced with "better" things that do not work as well, or perhaps do not work at all.

One program manager in industry sums up his approach to controlling optimism as pushing the worst case upon the engineers:

> First, you ask what is the worst thing that could happen. Second, you ask why it cannot happen to us. Third, you ask how you will know it has happened--what event or test will tell you. Fourth, you ask what you are going to do if it happens. These questions wring out most of the optimism and you get a chance to look at some real engineering analysis and hard facts.

Customer Relations

Weapon system development can be looked upon as one step in a long series of user disappointments. In the beginning there is the wish, and at the end there is the sobering reality of technology, schedule, and budget. Between the beginning and the end are disillusionments--popularly called trade-offs.

The user is the program manager's customer. The user may not be the direct source of the system requirements and may be represented by a requirements activity. In that event, the program manager has two customers--and a more complex problem of coordination. The whole purpose of weapon system development is to satisfy the user's need. The program manager has to face the fact that he may have an unhappy customer from the beginning. Moreover, the customer will become even more unhappy when problems which will inevitably arise during development force him to retreat still further from the system capability he wants. Trade-offs will have to be made throughout the development process. Since the user is the customer, he must participate in the trade-off decisions. If the program manager attempts to make these decisions unilaterally for the user he is courting disaster.

A direct pipeline to the user activity is the most effective means to obtain the necessary coordination between the program office and the customer. Informal channels are no less important than formal channels. Indeed, from the program manager's view, the informal channels are more important because they flow faster. The importance of coordination leads many experienced program managers to urge that one or more user representatives be brought into the program office right from the start. Some of the advantages these managers see can be obtained in no other way:

- The program office must have a solid feel for the system requirements--why they are important, how they were established, whether they could be changed, and what the impact of a change might be on operational effectiveness. The best way to get this feel is for your engineers to talk with the people who know--not from reading papers.

- The user must understand the problems being encountered during development. If he isn't where the action is, he will not understand the problems and cannot respond to them intelligently.

- The user has a tendency to upgrade the requirements, especially if everything seems to be going well, trying to get back some of what he lost earlier in trade-offs. If he doesn't know what problems still remain to be solved, he can have too rosy a view of only a small part of the whole program picture.

- The user ordinarily doesn't have a good grasp for how everything ties together in the program plan. He wants changes made without really comprehending the probable impact of the changes on technical performance, schedule, or cost risks. If the user develops an understanding of the complexity of the undertaking, he is going to be a lot easier to live with. Contact with the program office should help achieve this goal.

- Some decisions have to be made quickly. A user representative will know how to get an expedited response when it is needed.

The need to check requirements directly with the user is illustrated by an example:

> During the Korean War an urgent requirement was received for an antitank warhead capable of penetrating 11 inches of armor. Since we knew that it would be impossible to fire perpendicular to the armor under all circumstances, we took a nominal value of 60 degrees for the obliquity of penetration and designed a shaped-charge warhead capable of punching a hole through 18 inches of armor. This weapon was to be delivered to the operating services in great haste. Some of us became curious as to the motive power employed by Russian tanks that would enable them to run around over rough terrain carrying armor 11 inches thick. Upon investigation, we found that the actual armor of the tanks had a thickness of somewhere between three and four inches, and that the specification given us had resulted from the correction for obliquity having been made twice before, while the specification was coming through channels. It is this type of well-meant distortion that makes it essential for the designer to question his specifications and to go back to primary sources in order to develop a real understanding of his problem and the basis for the need, if he is to create a successful product.*

A similar need for direct contact arises when the first operational systems are delivered to the user. The program manager and his top people should go into the field and work with the users. The product has to be sold. One program manager states:

> If you sit back and wait to hear how it goes, you will get flak you won't believe. Everyone

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*William B. McLean, of U. S. Naval Ordnance Test Station, China Lake, California, quoted in George A. Steiner and William G. Ryan, Industrial Project Management, pp. 38-39.

> up and down the line will get so upset with the shortcomings, real and imagined, that you won't even have a chance to be heard. Work with the user, explain why things are the way they are and the impact of changes on funds and schedule objectives, solicit his cooperation, and show an interest in getting the bad points fixed as soon as possible. The user is happier, and you can maintain the momentum of the program.

Logistics Considerations

Design cannot be treated separately from reliability and maintainability considerations in the development of a weapon system. Good results are what we want. Bad results can be obtained in either of two ways: by a design which produces a system that is not effective although the system is reliable and easily maintained, or by a design which produces a system that is never working when it is needed. Which condition is worse makes for an unproductive debate.

The program manager's problem is that design and development engineers on the one hand, and reliability and maintainability engineers on the other, are each specialists in a sense. The designer tends not to worry enough about logistics considerations. The logistician tends not to be enough concerned about the operational effectiveness of the system. The battle is usually joined on the proposition of who should dominate the other. The designer dominates (as ultimately he should), but schedule and cost objectives usually go out the window in a follow-on program of system fix. Resolution of the issue of dominance is not the problem--the problem is balance and coordination to achieve something more in concert than either specialist would achieve separately.

The objective of weapon system development is to get something you do not have now. Consequently, at least in the early program phases, performance objectives and criteria must have a dominant voice. But this does not

necessarily imply that design decisions should be made in isolation from logistics considerations. The trick is to find a way of fitting the two activities together on an informal, day-to-day basis--getting across the idea that good design includes logistics considerations and that the logistician can help the designer get a workable design. The key seems to lie in putting these activities together early in the design phases and encouraging logistics inputs before design decisions become frozen. If the logistician reviews only the finished design, changes he suggests are likely to have unexpected impact on the designer's work. The designer becomes defensive about his design because he doesn't want everything upset. The logistician feels ignored because the designer is, in fact, ignoring him.

The need for this pooling of design and logistics considerations is obvious. How can it be achieved? One effective technique is in the use of life cycle cost analyses. Although all costs cannot be dealt with by these analytical techniques, the identification of what drives the major cost elements over the life of a system may be a startling revelation to the designers. Training, maintenance, and manpower costs are likely to exceed their wildest imaginations. Life cycle cost studies give the designers a sense of appreciation for the costs of their designs and how those costs can be affected by changes in their designs. Life cycle cost cannot be developed without defining and comparing maintenance strategies. Alternative strategies and their costs are the tools the logistician and the designer need to obtain logistics considerations in system design.

Experienced program managers are agreed that informal working arrangements and close physical proximity are

essential if you are going to get the best out of both specialties. They are also agreed that conflicts between the designer and the logistician are no different from those encountered when any two competing specialties bear on a common subject. It is one more example of what many believe to be the most serious management problem faced by the program manager--control and integration of specialty interests.

Another kind of problem is the tendency to specify reliability and maintainability goals at the outset of the program as if they were something entirely apart from design. Often the goals are unattainable. Even more likely, demonstrating their achievement would be possible only at a prohibitive cost. This sort of technical never-never land weighs heavily on the designers and is responsible for some of the antagonism the designer often displays toward the logistician. Whether they are realistic or not, reliability and maintainability requirements generate cost; unnecessary requirements generate unnecessary costs. But, even apart from the effect on program costs, unattainable or unmeasurable requirements drain technical effort and divert management attention away from the main-stream problems. This kind of situation is fertile ground for breeding what one manager calls "the reliability numerologist"--a fellow who is engaged in spinning an endless web of numbers, which are manipulated, massaged, extracted, projected, and predicted. The trouble is that the numerologist doesn't sit quietly in the corner wasting a small amount of time and money. He gets everyone into the act, checking this and that, and he wastes an unbelievable amount of time and money.

Technical Futility

Unattainable technical objectives--unattainable in the sense of obvious incompatibilities with schedule and

cost constraints--sap the technical morale. They also siphon off the technical effort in a never-ending exercise of paper products explaining why schedules are being missed and what is being done (supposedly) to attain the desired technical objectives.

> There is a school of thought that believes requirements should be set beyond the level of normal expectation, in order to push the state-of-the-art and insure that the maximum achievable level of performance is attained. Results achieved in this manner are almost universally at high cost and not justified from the standpoint of cost-effectiveness. The technique of setting unattainable performance goals might be effective for a limited research and development program but is not appropriate where total system cost is already large, and where the cost of reaching for the last ounce of performance is economically impracticable.*

A program may be saddled with unattainable technical objectives at the start. It is more likely, however, that they are a product of inflexible response to problems uncovered during the development. Technical objectives must be treated as goals and not as unchangeable requirements. They must be reexamined in the light of known facts and in the context of continuing technical-schedule-cost trade-offs. A practical, flexible response to problems is an essential attribute of effective management.

In-House Research and Development

The Services have established a number of research and development laboratories covering a wide range of technical and scientific fields. Government laboratory personnel often serve as technical monitors for program

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*National Security Industrial Association, op. cit., p. 32.

offices on contracted research and development work. They also do research, design, and development work in their own right, utilizing valuable capabilities which are sometimes overlooked in systems acquisition.

For a program manager, these laboratories represent resources which can be exploited in the development of a weapon system. Some laboratories have outstanding capabilities in their scientific fields. They may be able to do better research and development work than many contractors. Several program managers observed that in-house research and development activities could often respond faster than a contractor for two reasons: first, the lead time for negotiation and award of a contract is eliminated; second, the technical team is in being--it does not have to be assembled.

In-house developments, however, carry their share of management problems. The primary one is the difficult process of transferring technical knowledge from a government laboratory to an industrial contractor. Technical knowledge involves such matters as shop practices, details of layouts and processing, and other information which rarely, if ever, get reduced to writing. Furthermore, there is a considerable difference between fabricating some development models for test and producing a quantity run of production items. In-house developments often suffer from the attempt to go from development to production without adequate production engineering. Scientists and engineers with a special talent for new developments usually are not very much concerned about the problems of producing in quantity what they have created. Consequently, when a system is to be produced by a contractor who did not participate in the development, there are likely to be more problems than would be expected when the producer is also the developer. Program managers can minimize the transition

problem by being sure that potential producers are brought into the program early enough in development to work with the laboratory and build a base of engineering knowledge to cope with technical problems in production.

In addition to these government-owned laboratories, each of the Services has one or more sponsored, not-for-profit organizations--under contract to and working for the Department of Defense--to assist it in its development programs. These organizations are known as Federal Contract Research Centers (FCRCs). Some of them are system engineering oriented, and provide technical management and coordination of the Services' contractors. Others are laboratory oriented, undertaking research and development of new weapons. Still others specialize in paper studies and analyses, and contribute much to the cost-benefit evaluations supporting system trade-off decisions.

The System View

A system is not an assemblage--although many systems have evolved in a way exactly fitting the artist's definition of "assemblage"--"an artistic composition made from scraps, junk, and odds and ends."

The system view is something which the program office provides for the supporting functional elements. It is also something which has to be maintained within the program office. The program manager must have a technical deputy he trusts--someone responsible for assuring that subsystem elements are more than merely compatible. They must be designed as part of a harmonious system and not an assemblage. The need for a technical deputy does not suggest that the program manager can or should avoid all technical problems. System engineering is only one of a lot of things he cannot avoid, but he cannot be the system engineer and also give all other matters the attention they require.

The system view is also needed to control engineering optimism. It seems to be a law of nature that as the development progresses, the system will get bigger and never smaller, heavier and never lighter--no matter how conscientious the planning and system design. System trade-offs will be essential, and the system view can be obtained only if you stand apart from subsystem partisanship.

Measuring Technical Progress

> The first concern of most managements when considering a new development is whether the project is being completed within the original budget. Its second interest is whether the project is being completed in scheduled time, but it is concerned with time only because "time is money". This principle is so deeply ingrained in business that time is considered almost synonymous with money. Considering these two constraints, where does technical performance fit into this syndrome? Does it hold a superior position (as some technical writers have stated) or a lowly one (as others have said with some bitterness)? The correct answer is neither. In fact, cost and time cannot be measured except against technical goals. The question of how much cost or how much time means nothing unless it is accompanied by "to achieve such and such a technical performance".*

The main reason for focusing on budgets and time is that they are easy to measure. Costs incurred and the time that has elapsed are easily determined. Actual costs and the elapsed time can easily be compared with an earlier estimate of the cost and time it would take to do the whole job to obtain a measure of progress. The result is a measure of progress--of how fast money is being spent. What is not known is anything about what you are getting

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*Peter C. Sandretto, op. cit., pp. 133-134.

for your money and you cannot come to grips with the crucial issue: How much is it likely to cost and how long is it likely to take to get done what you need to have done?

Measuring progress in a useful sense involves two things: a measure of achievement and a measure of cost directly correlated with the achievement. In addition, there must be confidence that what has been achieved will not have to be done over again. This implies concurrent test and evaluation tied to milestone events to ensure that the costs are correlated with real achievements.

Techniques which have evolved for measuring progress are based on a simple proposition: comparing cost and time for accomplishing small, discrete, defined pieces of the whole job with earlier estimates for accomplishing those defined pieces. Each successive piece of the job can be aggregated with those preceding to give a measure of change in the direction or in the rate of the variance from plan. These pieces are called "work packages." The definition of work packages, tracking the cost and time to complete them, and comparing actual cost with earlier estimates, are the core elements of a management information system in which cost and time can be measured against goals. When combined with a test and evaluation program tailored to be compatible with the measures of cost and time, they are the essential elements in measuring technical progress.

Keep It Simple

> The extreme ingenuity of this system rather blinds one to its utter uselessness.

This quote, attributed to a British naval officer, has a message: Keep everything as technically simple as possible. Use proven components and subsystems, and proven technology, whenever possible. Avoid frills. More than one program

has suffered because no one challenged the addition of a new, sophisticated component for some additional feature which added nothing to the basic purpose of the weapon system.

CHAPTER FIVE

SCHEDULE PROBLEMS

Optimism

The odds are that the program manager is in schedule trouble even before he has a chance to create his own problems. He is in trouble at the outset because almost invariably everything has taken longer than anyone supposed it would. It is a safe bet that much of the program lead time has melted away in the technical and administrative processes of defining requirements and conceiving the program. By the time the program is shaped up, the user is already in a froth. In spite of the fact that everything took longer in the past, there is an all but universal feeling that it will be entirely different in the future. The pressure is on. It may even be possible to make up some of the lost time--more pressure is put on. Optimism becomes the order of the day. Program schedules are laid out. At worst, they are arbitrarily made to fit an inflexible Initial Operational Capability date, and there is such a faint chance of success as to amount to none at all. At best, they are based on a view of paradise: everything works right the first time, nothing goes wrong, nobody makes a mistake.

The system requiring SECDEF decisions at key program points, and the DSARC program reviews which are a part of that process, will temper this emphasis on accelerated schedules. Nevertheless, it is a fact that time is the greatest strain for program managers.

Time is likely to be a strain even in the best of circumstances. It seems to be a rule of natural law that everything takes longer--even the things that seem simple.

The more complex the development undertaking, the less likely we are to understand the interrelationships among its many parts and the greater is the likelihood that unknowns will plague the program schedule. Weapon system developments are complex undertakings no matter how reassuring the scheduler's charts may appear.

<u>Inadequate Planning</u>

Experienced program managers point to three basic weaknesses in schedule planning: inadequate networking, inadequate consideration of administrative processing time, and inadequate provision for contingencies.

Planning and controlling are closely related. They are so closely related that there is a tendency to assume that the system used to control the program determines the kind and detail of planning which should be done. This is wrong. You may decide that you do not need a sophisticated, computerized control system (like PERT), but you still need to lay out the grubby details of what you are going to have to do. Networking (which is usually associated with PERT) is a way of portraying what has to be done. Its advantage is that it portrays the interrelationships among all the things that must be done. It shows the dependency of future activities and events on previous efforts. It relates activities and events to each other over time.

Inadequate networking is a common complaint in hindsight. If they had it to do over again, many program managers would have planning done in more detail, not less. There is agreement that more detailed networking would have resulted in fewer important things being overlooked. One program manager overlooked the fact that no allowance had been made for procurement lead time--the

schedules assumed a zero delay between the time he was ready for a contractor to start work and the time a contract was awarded. Needless to say, he had serious schedule problems. There is also agreement that detailed networks improve risk analysis by making the interrelationships and dependencies of events more visible. Networks also improve effective test planning for the same reasons.

Another advantage of detailed planning is the grasp of the program which the program manager gets by working with the networks. One program manager puts it this way:

> Getting involved in the networking gives you a feel for the whole program. You get an understanding beyond the buzz phrases. You can see the relationships among things and, most important, you can talk intelligently about your whole program--why you are doing things and when they must be done. You get a feeling of confidence about your grasp of the program that is communicated to others. They, in turn, get a sense of confidence in your ability to manage your program. When people up the chain don't have that sense of confidence, you find that they take over the program.

Inadequate consideration of the time it takes to process paper through the administrative mill is another weakness. It is a problem right from the start because it takes longer to build up the program office than was planned. Schedules start to slip from day one, and the program manager is hard pressed to find other means of accomplishing what he intended to do in his own office.

Problems are encountered wherever there is paper to be processed or approvals to be sought. Some of the worst and most common problems of optimistic scheduling are in processing procurement actions. It takes a long time to pull together the pieces of a solicitation package and

to go through the many steps leading to a contract award. In some cases it takes an unbelievably long time. This can be an area of real concern because dovetailed schedules can be disrupted and it can become impossible to meet the planned commitment of funds.

It appears also that you cannot simply assume that those responsible for processing something really know how long it will take. Functional managers, too, seem to underestimate the number and impact of unknown problems. One thing you can do is to talk to other program managers and find out what happened to them. What happened to their program is likely to be closer to what will happen to your program than anything else you hear. Problems have a way of staying much the same for a long time and affecting the next in line just as they did the one before.

When everything has been carefully scheduled and thoughtful estimates applied at every stage, there is still one problem: It will not work out that way. No matter how careful or how thoughtful the plan is, something will go wrong. There must be slack between schedule milestone events or the program will be playing catch-up ball the whole way. It is not enough only to have slack. It must also be hidden and kept secret from organizations working to target dates specified in planning documents. Once slack is discovered, it will evaporate and it will have disappeared when it is really needed.

Lack of Candor

The urge to present a favorable image to others leads many to discount what they know or think about the inevitable impact of a problem. It leads to sanitizing what they tell their boss. Judgment is replaced by a childlike faith that somehow the problems will disappear and no one will know they were ever there.

When the program manager thinks that he might succumb to this urge, he should pause to consider two pitfalls. First, it works only for a little while:

> The idea of "buttering up" a report to management so that they will hear only nice things and consequently think of your program in nice terms falls flat when the first major problem that you cannot cover up appears. Instead of being aware that you have been hard at work on a solution for weeks and something unforeseen occurred, top management will suddenly be confronted with a major problem. They can then become quite unhappy with the program progress. They had not been informed properly.*

Second, the program manager's own staff will do unto him what they see him do unto others. Things really do go out of control then. The boss is not likely to think that the program manager is not aware of what is going on in his program--the boss will know it.

The need for candor in reporting and assessing actual or potential problems is illustrated by viewing a program in the perspective of related programs. If delays can be reasonably anticipated in a program, there are options available to decision-makers. One option is to pour more money into that program to recover schedule. Another option may be to extend the use of an existing system and accept schedule delays in developing the new system. If problems are hidden long enough, the options may disappear. It may be impossible to extend the use of an existing system because necessary production lead time has been lost. There may not be time to replenish an inventory of spare parts deliberately reduced in anticipation of phasing out the old weapon system. Decision-makers are understandably inclined to be perturbed when viable alter-

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*Melvin Silverman, The Technical Program Manager's Guide to Survival, John Wiley & Sons, Inc., 1967, p. 62.

native decisions are reduced to one--panic!--because the facts were deliberately obscured earlier, when other alternative courses of action were still feasible.

Inadequate Control of Events

Schedule problems are not always thrust upon the program office. Some can develop inside the program office.

The natural tendency of scientists and engineers, whether in industry or in government, is to seek technical perfection. The natural consequence of this tendency is that they regard schedules as of secondary importance. Someone has to emphasize the fact that schedules are important--perhaps even more important than the last measure of small improvement in technical performance. In the words of one program manager:

> Design engineers will fiddle and tinker forever. If you let them alone, you are guaranteed to have schedule slippages and cost problems. Nothing will come out of the end of the pipe unless you push it out.
>
> One technique that works for me when I see them at the fiddling stage--making things a little better and not worrying about the schedule--is to shove an absolute deadline on them and tell them that we will just have to go with what is available then. As a matter of fact, it is often surprising how much they squeeze out of the last few weeks. They just don't like the idea of your going with less than the best.

Management Information Systems

Management systems are frequently mistaken for management. This mistake is most evident when people speak of management control systems--which really do not control anything. They should speak of management information systems, since these systems only provide data which

someone may use to focus on items going out of control. Management information systems can also provide so much data that control is impossible because no one can thresh the mountain of material reported. Modern computer technology has solved the problem of storing and retrieving data. It is one of the few items the program manager has in long supply.

Reliance on unanalyzed data is equivalent to assuming that systems--and not people--control. This assumption is a mistake. What the program manager needs is some way to analyze the data, to get rid of the chaff, and to have information presented in a form he can understand. Most important, he needs it in a form he can use; that is, in a form which will provide at least four things:

(1) A ranking of problem areas by criticality.

(2) An indication of potential trouble spots.

(3) Anticipated schedule slippage and cost overruns or underruns.

(4) A means of determining where management can withdraw resources to assist more critical phases.*

Management information systems can portray a false picture based on erroneous information as easily and prettily as they can display an accurate picture based on valid information. A realization of this fact is basic to a healthy skepticism in the MIC. This is not a new or novel idea:

> It may be difficult to obtain accurate and timely reports of progress. It is not uncommon among PERT users to receive feeder

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*John Stanley Baumgartner, Project Management, Richard D. Irwin, Inc., 1963, p. 49. Mr. Baumgartner has an excellent, and brief, discussion of a technique to do these things by what he calls "The Status Index" on pp. 48-60 and 175-177.

> reports indicating progress in accordance with plan; and then suddenly, in a two-week period, two or more weeks' negative slack is reported which means literally that during the two-week period no work or negative work was accomplished. A look at the expense report indicates normal expenditures; the quickly arrived at conclusion is that previous reports of progress were not correct. Frequently, in-house and subcontract working groups are reluctant to admit difficulties until the difficulties would have been discovered anyway. By the time the true schedule position is admitted the PM may suddenly find himself in serious cost and progress difficulty.*

What is true of the program office's system is also true of its contractors. The industry project manager may have an inadequate system to support him, and he may use inadequate techniques to ferret out the truth. If this is so, the information furnished to the program office will be wrong. More important, the contractor is likely to have schedule and cost problems resulting from inadequate control. In almost every case, the contractor's problems burn the program as well as the contractor. Consequently, it is simply good business practice to check out the contractor's methods before relying on them. Government people often assume there is in industry a degree of sophistication and skill in management that simply does not exist in a specific company. The existence of the skill must be verified, not assumed. "C/SCSC" (Cost/Schedule Control Systems Criteria) is essentially a specification intended to assure the completeness, accuracy, and integrity of different systems used by contractors to track cost and progress. The validation of an individual contractor's system by the government is a process of checking out his methods.

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*Ibid., p. 35.

While a validation gives assurance that the contractor has acceptable methods, it does not establish any specific requirements for reporting cost or progress to the program manager. The program manager must still establish and define his requirements in terms of what he needs to manage contracted work.

One program manager observed that it was amazing how little information he really needed and used to help him manage his program. His needs were basically satisfied by the relatively simple reporting requirements described by Mr. Baumgartner. At the same time, he also observed how easy it was for the program office to be carried away with information display--what he called "an artist's view of managing programs." A management information center is a wonderful piece of public relations--especially captivating for those who have never managed programs. One thing is certain, however: every program manager regrets any idea he may have had that he could really manage his program in the comfort of the big swivel chair in the MIC..

> In looking back at my experiences in development, including watching a number of Navy developments over the past few years, it seems quite clear that in most cases where a system gets into trouble a competent manager knows all about the problem and is well on his way to fixing it before his management systems ever indicate that it is about to happen. This happens if for no other reason than because the competent manager is watching what is going on in great detail and perceives it long before it flows through the paper system. That is to say personal contact is faster than form filling and the U. S. mails. A project manager who spends his time in his Management Information Center instead of roving through the places where the work is being done is always headed for catastrophe. The MIC can be an assist to the people who are involved in the project toward learning of after-the-fact

> problems, but that is roughly all that it can do, and its value even for this purpose is frequently questionable.*

Bureaucratic Apathy

Allied with the problem of administrative lead time is the danger of bureaucratic apathy affecting the program office. Its symptoms are long review and approval chains, slow responses to correspondence, a reluctance to seek or approve waivers from standard procedures, and a faith that the way something has always been done in the past must be the right way to do it. It is a sure sign that the steam is going out of the organization.

An occasional look at some routing sheets and at referenced dates in correspondence is about all that is needed to uncover the problem. An intolerance for the symptoms--especially for expressions of faith in the excellence of current practices--will go far to preserve the free spirit that is one of the important assets of program management.

Funding Changes

One of the rules of the program management game is that the only sure way to have money is to get rid of it. Until funds are obligated by contract, they may be snatched away for any number of laudable reasons--none of which benefits the program which loses its funds. One program manager describes the situation this way:

> If you want to protect your program, you have to fight for it. You especially have to fight for funds. One or another program is

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*Robert A. Frosch, "The Emerging Shape of Policies for the Acquisition of Major Systems," Naval Engineers Journal, August 1969, pp. 20-21.

> always in trouble and someone is sure to be looking for money. They want to swap their problems for your money. It may be a provincial attitude, but I think a program manager is expected to push for his program. That means two things: first, grab for your money; second, get it into contracts and work orders as soon as possible. You have to plan and schedule your contract actions early in the fiscal year. You have to make sure you are moving your money out as planned.

Changes in funding also have an impact on the psychology of schedules. Funding changes always result in schedule changes. Schedule changes may be necessary, but they hurt:

> A schedule is only as firm as the esteem given it by people working on the project. When schedules change frequently, whatever the reason, or where there are doubts and second guesses about the "actual" schedule, the validity of the schedule as an element of control is weakened.*

Notwithstanding his best efforts, it is a rare and fortunate program manager who does not have to absorb reductions in funds or reprogramming of funds to later fiscal years. Advance planning for these contingencies is recommended strongly. Higher authority is likely to want to know the impact of funding changes on ridiculously short notice and some advance planning reduces the turmoil of responding. In addition, an inadequately supported response is detrimental to maintaining one's image as a manager who is on top of his program.

Government-Furnished Material

Seldom, if ever, is there a program in which a single contractor furnishes the complete weapon system. Usually

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*Ibid., p. 34.

there are several contractors, whose products flow to the system integration contractor, along with other items furnished by the government. In many cases, major subsystems of the complete weapon system are assemblies of components, some furnished by the subsystem contractor and some received by the subsystem contractor to be joined with what he is furnishing. The crucial distinction between government-furnished and contractor-furnished material is that the government assumes a responsibility for the proper functioning and on-time delivery of government-furnished items. The contractor assumes this responsibility for items he furnishes, including items obtained from his subcontractors.

Government-furnished equipments (GFE) are physical components used in the system or as aids in the development of the system. Government-furnished information (GFI) is descriptive of the form and fit of the GFE to follow, specifying requirements which must be provided and functions performed--such as dimensions, weight, power inputs, outputs, and so forth. GFE and GFI are notorious for the schedule and cost problems they generate. If they are not furnished to the contractor when promised, the government is responsible for any consequent delay and for any added costs attributable to that delay. As a result, problems associated with GFE and GFI are a frequent source of claims by contractors against the government.

From the program manager's viewpoint, there are two kinds of GFE/GFI. In one case, there are items needed by his system prime contractor from another contractor, and the program manager has direct control over both contractors. In another case, there are items which are needed by one of his contractors from a source not under the program manager's direct control. A different organizational element may be responsible or, perhaps, a different Service.

There are problems of coordination to ensure adequate performance with both kinds, but they are more severe with items (and especially with development items) not under the direct control of the program office. Distance and differing responsibilities lead to a diminished sense of participation in the program. When coupled with an all too human tendency to shuffle off our problems on others, distance and indifference have potentially explosive implications.

GFI which must be fed into the program on schedule may be furnished on time solely to avoid unpleasantries. What may not be furnished is the knowledge that the GFE development program is slipping and that what was supposed to be definite, firm, and certain is very uncertain and likely to be changed. The program office assumes that the information furnished is reliable. Design decisions are made based on that information, and they, in turn, become the basis for succeeding design decisions. Changes in the GFI, which might well have been anticipated if there had been complete candor earlier, can cause a lot of wasted technical work. It might have been possible to work around the problem, but the opportunity to do so is lost if no one advises that there is a problem.

Prevention, not cure, is the only feasible remedy. Avoid system designs which force the program to rely on developmental items of GFE. That is sometimes impossible. In that case, the program office must monitor critical items of GFE and GFI furnished from outside sources as closely as it monitors the hardware for which it is directly responsible. This means getting out in the field, getting close to the work, and checking facts. Finally, the GFE managers have to be made a part of the program team through coordination meetings, where they can get a sense of their part in the enterprise and some feeling of responsibility for

its success. Face-to-face contact with the people who will be forced to live with the problems they generate is strong preventive medicine.

CHAPTER SIX

COST PROBLEMS

Sources of Cost Growth

The experiences of more than 30 major programs over an extended period of time give some indication of the problems of cost growth most likely to beset new programs. These program histories show that the factors contributing to cost growth and their approximate impact were:

- Changes in Cost Estimates--refinements of the base program estimate--accounted for 40 percent of the total cost growth.
- Engineering Changes--alterations in physical or functional characteristics--20 percent.
- Schedule Changes--changes in delivery schedules or program milestones--15 percent.
- Economic Changes--escalation adjustments in contracts and other changes in the purchasing power of the dollar--10 percent.
- Support Changes--changes in spare parts, training, testing, and other support requirements--7 percent.

A variety of other items made up the balance of some 8 percent of the total cost growth in these programs.*

Price Optimism

In much the same way as he inherits going-in schedule problems, the program manager inherits going-in cost problems. The odds are overwhelming that the initial, "first-pass" program cost estimate was too low. Price

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*Data from Selected Acquisition Reports (SAR) prepared as of June 30, 1970.

optimism is a term used to describe how this situation arises, and changes in cost estimates (the largest item by far in cost growth) are the result. Price optimism is mostly a result of the usual optimism we have in situations of great uncertainty--we do not grasp the import or magnitude of actual or potential problems. It is also partly a result of a self-serving bias that aggravates the situation.

> There is a natural tendency on the part of DoD and industry to foster unrealism in initial estimates of program cost, timing for hardware availability, and capability to meet performance criteria. First-pass cost estimates of new weapon systems or a new defense capability tend to be inaccurate because of lack of definition and objectivity, coupled with inadequate estimating skills. Insufficent attention is given to what is realistic in the sense that it is practical of attainment in the immediate or foreseeable future--based upon experienced and knowledgeable judgment.
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> . . . .
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> Parochial interests on the part of both DoD and industry tend to produce unduly optimistic estimates. Competition for military roles and funds to promote favored programs, and the desire to maintain or increase business growth and backlog, have resulted in a pattern of marketeering and overselling. From Congress down the acquisition chain, realism too often has not been recognized as an essential element of evaluation and decision making.*

The cost estimating problem is the basic problem. Optimism slants the result because we really do not know the right answer. If we knew what the right answer should be, it would be possible to root out the facts to confront the fiction. It is another story when fact and fiction are indistinguishable. Since, as Dr. Frosch says, we purchase objectives in development, and not objects--since what we purchase does not have real

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*NSIA, op. cit., pp. 12, 14.

characteristics and there is no defined real price--then program cost estimates must necessarily be very uncertain and valid only in very gross terms. Optimism will not be bounded effectively.

Two operating concepts are implicit in the uncertainty that seems to be inherent in program cost estimating. First, truly effective cost control can be achieved only by constraining initial program requirements. Second, established requirements must be repeatedly reexamined in the light of unfolding knowledge of their cost implications.

Constraining the initial requirements is one way to be sure that program costs are not greater than they must be. While we may not know what something will cost in absolute terms, we do know that additional requirements will add to its cost. Unnecessary performance requirements which are beyond a state-of-the-art, disruptive changes in requirements, concurrency of development and production when designs are likely to change, all add to the total cost--and result in more cost than need have been incurred.

As development progresses, the probable cost of achieving one or another stated performance objective becomes more evident. At the same time, the cost implications of backing off from the established requirements can be assessed more accurately. If the cost of achieving the stated objectives is going to be greater than anticipated, it is necessary to ask whether lesser requirements are now acceptable or whether the added costs are inescapable. What is essential is that there be an opportunity to make these trade-off decisions before everyone is committed to the higher cost alternative. The program information system must alert management to the fact that a trade-off decision must be made in a context where no decision is equivalent to opting for inevitable cost increases.

Engineering Changes

Changes and the need to control changes were discussed in Chapter Two. The focus there was on formal changes: changes issued by the contracting officer which directly and explicitly address their effect on schedule and cost objectives. Some changes are doubtless going to be essential to embrace new technology or to respond to a changed threat. Change control seeks to distinguish the essential from the unessential. It seeks to avoid the disruptive, and perhaps catastrophic, effect of innocent-looking, nice-to-have changes. Change control implies a searching examination of the effect a change may have on schedule and cost objectives before a decision is made. Change control is rooted in a conviction that there is no such thing as a technical necessity entirely independent of the cost and time to achieve it.

Formal changes are issued by the contracting officer only after prescribed reviews and coordination with the program office. They are not necessarily easy to control, but at least they are easy to identify.

There are other changes not so easy to identify. Collectively, they are called constructive changes. They amount to the same thing as formal changes except that no one has directly and explicitly addressed their impact on schedule and cost. The government's responsibility for both types of changes is essentially the same. The effect of a constructive change on schedule and cost is not addressed before the change: the government simply pays later when its liability for claims by contractors is the subject then to be addressed.

A list of these informal, constructive changes would include:

- Defective specifications which cause the contractor to do extra work.
- Requiring or authorizing work that is not specified under the explicit terms of the contract.
- Directing the contractor to do work in a way not required by the terms of the contract.
- Adding inspection requirements.
- Requiring adherence to schedules notwithstanding delays caused by the government--such as late delivery of GFE.

Constructive changes can easily take place in the informal process of program management--in meetings and by correspondence--especially when the program manager or his deputy is involved. Such changes are prone to arise in situations where a contract is viewed (as some technical people view it) as a fussy necessity and something to be largely ignored.

There are three things a program manager can do to control these changes. First, he can make his position on the importance of the contract terms clear to his own staff and the contractor. If the program manager intends that there be no informal changes, he had better make it clear to everyone. Second, he can practice what he preaches. Third, he can encourage (even demand) active participation by his legal and contract advisers in the day-to-day operations and activities of the program office.

Schedule Changes

Program schedule changes cost money. It costs if the schedule is stretched-out, and it costs if the schedule is accelerated.

Stretch-outs add to total program costs because fixed operating costs of contractors and laboratories (depreciation of buildings and equipment, management salaries, and

other overhead) will be allocated over a longer period of time. Those costs will be allocated at a higher rate, also, except in the unlikely event that additional work is obtained from another source to offset the lower level of effort in the program. Additional costs are also incurred in reworking production engineering and other scheduling efforts. Finally, added costs may be generated by maintaining an engineering or other capability which cannot be effectively assigned elsewhere.

Acceleration adds to total program costs by requiring recruiting and training of new personnel, overtime and shift premium pay, acquisition of additional facilities and equipment, and duplication of scheduling efforts.

Schedule changes are often the result of changes in funding levels. Much of the time, there is little the program manager can do to protect his program against the effect of major budget reallocations. The best defense--possibly the only defense--is to make sure that higher authority knows in advance and in as much detail as possible what the consequences of budget changes will be.

Budgeting for Target Costs

There is a form of optimism which can be traced to budgetary myopia in the program office. It is myopic because it does not take into account future events, and it attributes to contracts qualities they do not have.

The most obvious manifestation of this optimism is treating cost reimbursement contracts as if they were for fixed dollar amounts. Budget people sometimes lose sight of the fact that the very reason for using that type of contract should effectively dispel any such idea. Program management people sometimes lose sight of the same thing. The basic reason a cost-reimbursement contract is used is

that the actual cost of doing the work is highly uncertain. The estimated cost is not a price--it is an objective. At the very least, one must anticipate the possibility (many would say probability) that the cost of the work will exceed the objective.

A similar form of the problem is often encountered in budgeting for fixed-price incentive contracts. A target price is negotiated. Recognizing that it is likely that it will cost more than the target price to do the work, provision is made in the contract allowing for a specified upward adjustment of the price. What often happens is that everyone forgets about the spread between the target and ceiling prices. The target price is the one everyone talks about, budgets for, and counts on--until the bill is received. There is then a realization that something important was overlooked, and a scramble ensues to find the funds.

A somewhat related problem is the tendency to ignore budgetary planning for changes and contingencies. The source of this problem is the same tendency to view contracts as setting unchanging, fixed dollar limits for the work needed. A little checking around and inquiring into the experiences of other programs will soon disclose that contract changes must be anticipated. Program managers can get some feeling for the possible magnitude of this problem by looking at what has happened in a few programs of comparable size and complexity.

<u>Unnecessary Documentation</u>

Unnecessary documentation comes in two varieties: not really needed at all; and not needed when it is required to be furnished and likely to change before it is really needed. In each case, the result is useless effort--and at avoidable expense. There is a large hidden cost, also. There is at

least one person (and usually more than one) who will study, critique, evaluate, question, and file every document which is prepared. Indeed, the cost of preparation is only a small part of the total cost. Follow-on costs after distribution must be enormous.

Industry sees the problem clearly:

> On many programs involving complex hardware, technical data such as drawings, manuals, forecasts, and various plans and procedures are required prematurely. These premature requirements result in excessive contractor efforts to meet initial commitments--often with inferior data--and extensive additional efforts to correct or redo the data. Government personnel must also review, comment on, and re-review such data. It is unrealistic to establish requirements for early submittals of many items of technical data without considering the status and availability of a firm technical definition of the equipment to which the requirement pertains.*

The problem looks much the same when viewed from within the defense establishment:

> I have seen overruns in expenditure and unnecessary effort generated by the fact that the linear sequencing of milestones had forced development of a complete maintenance and reliability plan for what was no longer the design, and had not been the design for three months. The machinery forced everyone to grind on and on because, after all, the maintenance and reliability milestones could not be missed without disaster and fear of cancellation of the project, even though the plan being worked out had nothing whatever to do with the hardware being designed.**

Different Appropriations

A different kind of cost problem arises because the program office deals with different kinds of funds.

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*NSIA, op. cit., p. 46.

**Robert A. Frosch, Naval Engineers Journal, p. 22.

Appropriations come in various kinds, with varying periods of authorized use, and program money management requires deft skills. One program manager described the problem in these terms:

> We all know that appropriations are not interchangeable. Funds for RDT&E cannot be reprogrammed for O&M or Production. The same conditions generally hold for all combinations. This means that it is important to program the right types of money to support all aspects of a project--the aggregate amount of funds is of quite limited value unless the pieces fit the categories of work to be performed. There are some very narrow overlapping areas where some interchangeability may be accomplished, but they are quite limited. Recognition and negotiation of these areas are best left to the experts--those in the Budget Office. Never underestimate the value of the man heading that office.

Similar problems arise through failure to budget adequate funds for travel and overtime work, although the very nature of program management activities will require much of both. Program managers often find that they do not have control of the budgeting or allocation of these funds. They must get in line with many other managers and compete for the funds they need.

A Matter of Emphasis

Cost control is largely a matter of continuing attention and emphasis. The problem is that most of the excitement is associated with technical performance and schedule objectives. In defense weapon system acquisition, the ultimate user--the fighting force--does not budget or pay for the development. The money flows through another channel and, naturally, the user is not especially conscious of or concerned with cost. What the fighting force wants is the best performance and the earliest delivery. Since it is not directly

concerned with the funding problem, it can emphatically voice its desires without worrying much about their cost implications. Moreover, as noted earlier, industry sources have a similar bias toward technical and schedule objectives. If cost objectives are going to be emphasized in any practical way, it will be only because the program manager assumes that responsibility. It may appear to others that he views cost in an unbalanced way--seeming to emphasize cost more strongly than technical and schedule objectives. That is probably the way it must appear if overall program balance is going to be achieved.

CHAPTER SEVEN

THE EFFECTIVE MANAGER

Peter F. Drucker says that the job of the executive is to be effective, and effectiveness is getting the right things done. Ineffectiveness is not synonymous with laziness. On the contrary, ineffectiveness is often characterized by a frenzy of busywork, a childlike fascination with, and concentration on, what is interesting, what is familiar, what one is good at doing--and a corresponding avoidance of what needs to be done. The hardest things a manager has to do is to wean himself away from what he likes to do and become adjusted to a diet of different activities.

Mr. Drucker assures his readers that effectiveness can be learned. He sees it being learned through five practices or habits of the mind which must be acquired:

(1) Effective executives know where their time goes. They work systematically at managing the little of their time that can be brought under their control.

(2) Effective executives focus on outward contribution. They gear their efforts to results rather than to work. They start out with the question, "What results are expected of me?" rather than with the work to be done, let alone with its techniques and tools.

(3) Effective executives build on strengths--their own strengths, the strengths of their superiors, colleagues, and subordinates; and on the strengths in the situation, that is, on what they can do. They do not build on weakness. They do not start out with the things they cannot do.

(4) Effective executives concentrate on the few major areas where superior performance will produce outstanding results. They force themselves to set priorities and stay with their priority decisions. They know that they have no choice but

to do first things first--and second things not at all. The alternative is to get nothing done.

(5) Effective executives, finally, make effective decisions. They know that this is, above all, a matter of system--of the right steps in the right sequence. They know that an effective decision is always a judgment based on "dissenting opinions" rather than on "consensus of the facts." And they know that to make many decisions fast means to make the wrong decisions. What is needed are few, but fundamental, decisions. What is needed is the right strategy rather than razzle-dazzle tactics.*

The first two items--managing the little time he can control and focusing on his particular contribution--have special relevance for military program managers. The items are related: The program manager has little time he can control because briefings, reporting, and budget presentations take so much of his time; but these are also the occasions for a special contribution only he can make. That contribution is the creation and maintenance of the program's image to the world outside the program office. One program manager puts it this way:

> The program manager's main job is to make the program look good. I don't mean to fake it. I mean to be on top of the program, to anticipate what the boss expects, what the budget people expect, what OSD expects, and even what Congress expects. The image of an energetic, capable program is a great asset in recruiting the people you want in the program office, and in obtaining the right kind of support from functional organizations. The morale and success of the program office staff are largely a reflection of that image. A good image results in cooperation and a bad image results in struggling all the time to get what you need. The program manager has to be the outside man--the salesman, if you wish to call

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*Peter F. Drucker, The Effective Executive, Harper and Row, 1966, pp. 23-24.

him that--and his deputy should run the in-house work.

Nothing dampens spirit faster than a system where everything stops at the program manager's desk waiting for his return from somewhere. If he is not careful, the boss can become the chief clerk and proofreader in the office--the one who checks everything to make sure it is right. Weighing the risks on both sides, there is a consensus among program managers that there is only one way to go. That way is to select the best people you can get, give them a free rein, and rely on being able to fix their mistakes without too much damage being done.

There is another consensus that weekly staff meetings are both a must and an adequate backstop to catch the really significant mistakes. If weekly meetings are not an adequate backstop, the problem is not organization but ineffective subordinates. The solution is not centralization of decision-making but replacement of personnel. This is just another aspect of being effective as a manager, which is the job of a military program manager.

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